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THE MARINE BLUE-GREEN ALGAE OF JAPAN

By

Isamu Umezaki

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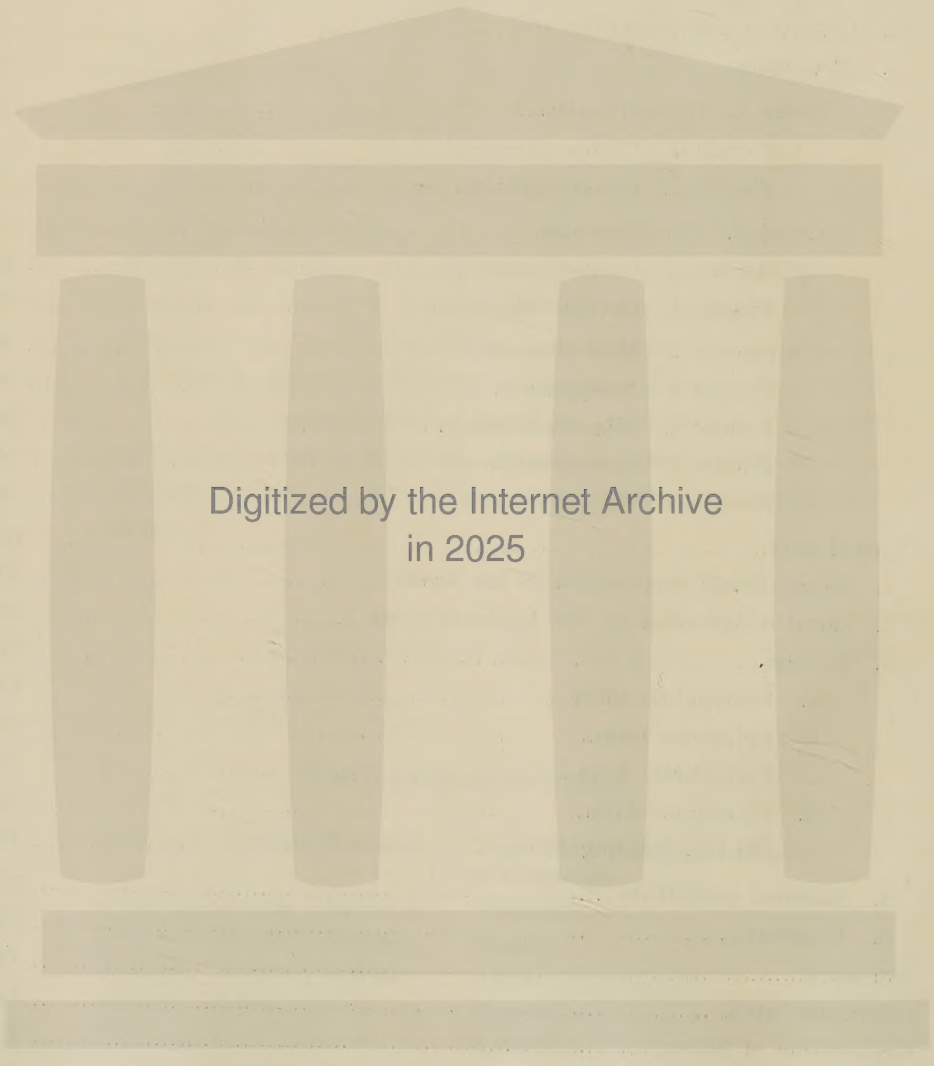

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The Marine Blue-green Algae of Japan

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Isamu UMEZAKI

(*With 1 Table and 21 Plates*)

Introduction

Historical: On the basis of specimens collected by C. Wright, who was a member of the North Pacific Exploring Expedition under Captain J. Rodgers during three years from 1853 to 1856, W. H. Harvey (1859) recorded many marine algae including four new species of Cyanopyta from Japan (and China), viz., (1) *Rivularia opaca* Harv., (2) *Lyngbya atrovirens* Harv., (3) *L. effusa* Harv., and (4) *L. atropurpurea* Harv., all four as occurring on Ryukyu and Bonin Islands. According to Harvey's manuscript on the marine algae of the Expedition of 1853–56, which was discovered and published recently by E. Y. Dawson (1959), two marine species were collected on Ryukyu: *Lyngbya majuscula* (Ag.) and *Rivularia nitida* (Ag.). In his publication G. V. Martens (1866) described a marine species of the blue-green algae, *Leibleinia australis* Kuetz., as occurring in the North China Sea, in addition to freshwater species (*Nostoc commune* Vauch. and *Rivularia lens* Menegh.). In "Revision des Nostocacées Hétérocystées" by E. Bornet & C. Flahault (1886–88), Harvey's *Rivularia opaca* was undetermined as species inquirendae; *Rivularia atra* was described as occurring on the Japanese coast on the basis of a collection by Y. Tanaka (in herb. Grunow); and *Leibleinia australis* Kuetz., which was reported by Martens (1866), was referred to *Calothrix crustacea*; and it was described as occurring on the Japanese coast. When M. Gomont (1892) made a revision of Oscillatoriaceae he placed both *Lyngbya atrovirens* and *L. atropurpurea*, which were described by Harvey (1859), as synonyms of *Lyngbya confervoides* C. Ag. G. B. de Toni (1895) listed all species, which were reported from Japan till 1895 by the above-mentioned persons, in his "Phyceae Japonicae Novae." The marine species are (1) *Lyngbya confervoides* Ag., under which both *Lyngbya atrovirens* and *L. atropurpurea* of Harvey were placed as synonyms; (2) *Calothrix crustacea* Thur., under which Martens' *Leibleinia australis* was placed as a synonym; (3) Tanaka's specimen in herb. Grunow was referred to *Rivularia atra* and under this species Harvey's *Rivularia opaca* was also placed as a synonym; and (4) *Scytonema polycystum* Born. & Flah., under which Harvey's *Lyngbya effusa* was placed as a synonym. A freshwater species *Spirulina subsalsa* Oerst. was described as occurring at Keelung, Formosa. *Nostoc commune* Vauch. and *Rivularia lens* Menegh., which were recorded as freshwater species by Martens (1866), are not found in de Toni's paper. *Dermocarpa Schousboei* and *Lyngbya*

confervoides were reported as occurring in Japan in Holmes' "New marine algae from Japan" (1895).

In his "Synoptic list of Japanese algae," ed. 1, K. Okamura (1902) listed 13 species of the blue-green algae, of which 5 were marine, viz., (1) *Calothrix crustacea* Thur., (2) *C. confervicola* Ag., (3) *C. scopulorum* Ag., (4) *C. aeruginea* Thur., and (5) *Rivularia atra* Roth. In its 2nd edition (1916), the following 11 marine species were more added: (1) *Oncobyrsa adriatica* Hauck, (2) *Dermocarpa prasina* (Reinsch) Thur., (3) *D. Farlowii* Boerg., (4) *Trichodesmium erythraeum* Ehr., (5) *T. Thiebautii* Gom., (6) *Spirulina subsalsa* Oerst., (7) *Lyngbya confervoides* Ag., (8) *Richelia intracellularis* J. Schm., (9) *Scytonema polycystum* Born. & Flah., (10) *Brachytrichia Quoyi* (Ag.) Born. & Flah., and (11) *B. maculans* Gom. In 1902 when F. Boergesen described *Dermocarpa Farlowii* in his "The marine algae of the Faeröes," a specimen of Dermocarpa growing on *Myelophycus caespitosus*, which was collected by Y. Yendo at Enoshima, was observed. Afterwards, the specimen of *D. Farlowii* named by Boergesen was removed to *D. protea* Setch. & Gardn. by J. Tokida (1930, '38) who, at that time, also collected *Oncobyrsa adriatica* Hauck in addition to *D. protea* at Kominato and Cape Inubo, Chiba Prefecture. Okamura's "Algae Japonicae Exsiccatae," no. 100, *Brachytrichia Quoyi* (Ag.) Born. & Flah. came from specimens collected at Toyohama (Owari), Aichi Prefecture, July 1902, by Okamura himself. In Matsumura's "Index Plantarum Japonicarum," vol. 1, Crytogamae (1904), 18 species of Cyanophyta (as Schizophyceae or as "Suizenji-nori no tagui" in Japanese) of which 6 are marine species—*Calothrix crustacea* Thur., *Dermocarpa Schousboei* Born., *Lyngbya confervoides* Ag., *Rivularia atra* Roth, *R. opaca* Harv., and *Scytonema polycystum* Born. & Flah.—are listed. *Trichodesmium erythraeum* Ehr., which was found occurring in the red tide off the coast of Tosa (Kochi Pref., Shikoku), and *T. Thiebautii* Gom. were recorded by Okamura (1907). In Okamura's "Icones of Japanese Algae," vol. 3, no. 7 (1915), *Brachytrichia Quoyi* (Ag.) Born. & Flah., which was collected from Formosa, Ryukyu, and various localities of Honshu, was illustrated. *Oncobyrsa adriatica* Hauck was again introduced in Okamura's "Sorui-Keitogaku" (1930) and "Nippon Kaiso-shi" (1936). In a text book "Fuyu-Seibutsu Bunruigaku," ed. 1 (1932) by S. Kokubo, eight plankton species of Cyanophyceae of which two, *Trichodesmium erythraeum* Ehr. and *T. Thiebautii* Gom., were described as occurring in Japanese marine waters, were reported. Y. Yamada & T. Tanaka (1934) recorded *Dermocarpa protea* Setch. & Gardn. and *Rivularia atra* Roth var. *hemisphaerica* Born. & Flah. for the first time from Hokkaido (Utro, Cape Shiretoko). In a great book, "Nippon Kaiso-shi" by K. Okamura (1936), the blue-green algae were dealt with as a supplement because of the poor knowledge of these algae in Japan, and only four species were included in the book: *Oncobyrsa adriatica* Hauck, *Phylloderma sacrum* Suring. (freshwater species), *Brachytrichia Quoyi* (Ag.) Born. & Flah., and *Nostoc verrucosum* (L.) Vauch. (freshwater species). In 1940 Y. Yoneda recorded *Lyngbya semiplena* (C. Ag.) J. Ag., *Oscillatoria chalybea* Mertens, and *Calothrix parasitica*

(Chauv.) Thur. in his "Cyanophyceae of Japan," V, serial reports (I–VII) of which all dealt with fresh and thermal water species, as occurring in marine water. In his "Reference and Illustrations of Plankton, 1, Cyanophyceae" K. Akatsuka (1951) described numerous plankton species of Cyanophyceae in both fresh and marine waters in Japan, but all the species have never been reported in any botanical publication. The following 16 species and 3 varieties are from the marine plankton: *Dermocarpa decyliosoleniae* K. Akat., *D. Leibleiniae* var. *pelagica* Wille, *Oscillatoria Bonnemaisonii* Cr., *O. nigro-viridis* Thw., *O. miniata* (Zanard.) Hauck, *O. margaritifera* Kuetz., *O. brevis* Kuetz., *Trichodesmium erythraeum* Ehr., *T. Hildebrandtii* Gom., *T. tenue* Wille, *T. Thiebautii* Gom., *T. contortum* Wille, *Haliarachne pacifica* K. Akat., *Katagnymene pelagica* Lemm., *K. spiralis* var. *capitata* Lemm., *Richelia intracellularis* J. Schm., and *Rivularia atra* Roth. T. Tsujita (1956) found an explosive multiplication of *Trichodesmium erythraeum* Ehr. and *Trichodesmium* sp. in the waters of western Kyushu, which we call the red water. H. Hirose (1957) discovered and reported 14 species of marine blue-green algae on the Shiaku Islands in the Seto Inland Sea. T. Tanaka (1956) made a survey of the marine algal flora of the Amami Islands and reported 4 species of the blue-green algae in addition to numerous algae of other groups: *Lyngbya majuscula, L. confervoides, Symploca hydnoides,* and *Rivularia atra.*

As mentioned above, floristic and systematic studies of the marine Cyanophyta in Japan have not yet been extensive, especially when they are compared with the freshwater species as well as the marine algae of other divisions. In 1947, Prof. Y. Yamada of the Department of Botany, Faculty of Science, Hokkaido University, suggested "The flora of the marine blue-green algae of Japan" as my graduation thesis; and I started to work upon this subject at that time. In April 1948, I transferred to the Department of Fisheries, Faculty of Agriculture, Kyoto University, where since that time, I have been studying under the guidance of Assistant Prof. Y. Yoneda. And, since several years ago I have made more progressively my study with his advices of Dr. F. Drouet of the University of Arizona, Arizona. Results of my study have been reported fragmentarily (1950, 51, 52, 52 a, 53, 53 a, 54, 55, 55 a, 56, 56 a, b, c, 58). The present paper deals with the floristic composition and systematics of the Cyanophyta which occur on the whole coast of Japan, from the Amami Islands to Hokkaido, and with their ecology, their geographical distribution on the Japanese coast and in other parts of the world, their seasonal periodicity, and their economic importance.

Acknowledgments: I wish to give my most cordial thanks to Assistant Professor Y. Yoneda, under whose guidance the present work was carried out, and also to Professor Y. Yamada, who suggested the present subject when I was a student in his department and who permitted me to make free use his library. To Dr. F. Drouet I am indebted for much valuable advice on many matters and moreover for his kindness in reading the manuscript of the present work. Furthermore, I am obliged to Prof. S. Kitamura of the Faculty of Science, Kyoto University, and

to Prof. S. Ueda of the Tokyo University of Fisheries, both of whom kindly allowed me to use their libraries. My thanks are also due to the following herbaria and persons who kindly sent me types and other valuable specimens: Monsieur P. Bourrelly, Laboratoire de Cryptogamie, Museum Nationale d'Histoire Naturelle, Paris; Dr. F. Drouet, Herbarium of Francis Drouet, Arizona; Dr. A. Ercegović, Institut d'Oceanographie et de Peche, Split; Mr. K. C. Fan, Taiwan Fisheries Research Institute, Keelung; Dr. J. T. Howell, California Academy of Science, San Francisco; Dr. J. Th. Koster, Rijksherbarium, Leiden; Dr. C. S. Nielsen, Herbarium, Florida State University, Tallahassee; and Dr. G. F. Papenfuss, Herbarium, University of California, Berkeley.

Special Part

1. Morphology

The plant: Among the Chroococcales the word plant is used for a single free cell or a group of cells jointed together, usually in a gelatinous matrix, which forms a single entire globule, cushion or layer; among the Oscillatoriales it is used for a single trichome, a single filament, or a variably shaped stratum, cushion, or sphere of many trichomes or filaments or a group of filaments, usually enclosed in a gelatinous sheath.

The gelatinous matrix (sheath): This term is used here for the sheath enveloping a group of cells in the Chroococcales and for the common sheath enclosing a group of filaments in the Oscillatoriales. Many plants of the Chroococcales are surrounded by thick and often diffluent sheath. In the Nostocaceae, Rivulariaceae, and some Stigonemataceae, the spherical or cushion-shaped plants consist of gelatinous sheaths in which the filaments are immersed regularly or irregularly, loosely or tightly.

The sheath: The term sheath is generally here employed for the cylinder of gelatinous matter surrounding one or several trichomes in the Oscillatoriales and to the gelatinous matrix investing a single cell in the Chroococcales. A good example is that of a Lyngbya, the trichome of which is enveloped by a cylindrical, hyaline or coloured, firm or geletinous, homogeneous or lamellated sheath. That of a Phormidium is always diffluent, and the naked trichomes are immersed in the gelatinous stratum. In the Rivulariaceae the upper portion of the sheath sometimes disappears or it becomes dilated or repeatedly lamellated. In the Chroococcales each cell is usually enveloped by a thick hyaline sheath. The chemical composition of the sheath and the gelatinous matrix is mainly of pectic substance; and in certain species, celluloses, hemicelluloses, schizophycose, or cutin are also present.

The cell: The term cell is used here for the protoplast surrounded by a membrane. In the protoplasm two regions are distinguished: a peripheral region (chromoplasm) which contains the photosynthetic pigments, and a colourless central

region (central body or centroplasm). The pigments of the blue-green algae are chlorophyll a, carotinoids (β-carotine, myxoxanthin and myxoxanthophyll), xanthophyll, c-phycocyanin and c-phycoerythrin. Fuscochlorin and fuscorhodin are found in *Calothrix scopulorum*. The first product of photosynthesis is glycogen, and it is stored as glycoprotein in the chromoplasm. In the protoplasm there are no mitochondria or central vacuoles. The nuclei of the Cyanophyta differ from those of algae and plants of other divisions; the nuclei have no nuclear membranes or nucleoli, and mitotic divisions has not been observed.

The filament: This term is restricted to the Oscillatoriales. It consists of a trichome (uni- or multiseriate chain of cells) and its sheath. The most simple filaments are those of a Lyngbya or a Calothrix, the sheaths of which contain single trichomes, while the more complicated form is that of a Dichothrix or one of the the Vaginarieae in the Oscillatoriaceae in which two or more trichomes are enclosed in a sheath. The gelatinous spheres or cushions of many Nostocaceae and of Brachytrichia in the Stigonemataceae, the sheaths of which are sometimes entirely diffluent, are composed of numerous loosely contorted filaments; while in a Rivularia or a Gardnerula, the densely parallel filaments in the gelatinous sheath form a cushion-shaped, hemispherical, or branched plant.

The trichome: The term is here used only among the Oscillatoriales. An uniseriate or multiseriate chain of cells is called a trichome; it is naked or invested in a sheath. In Spirulina, Arthrospira, Oscillatoria, Sphaeronema, and Skujaella the trichomes are naked, while in other genera of Oscillatoriaceae they are generally vaginate. Each cell of the trichome is partially or entirely separated from another by a thin cell membrane (cross wall).

The cross wall: This term means the cell membrane between cells and is employed only to cells of a trichome. In filamentous species the cross walls and the constriction of the trichome where it occurs are of importance as a specific distinction. In the Oscillatoriaceae there are sometimes granules along the cross walls which are also of taxonomic value.

The granules: This term is here applied to the highly refractive substance in the protoplasm. Granules, which are known as cyanophycin, or protein substance, are often located against the cross walls of trichomes, especially of some species of Oscillatoriaceae; and their presence is used as a taxonomic character, because they possess a marked degree of persistence in position.

The heterocyst: Certain vegetative cells enlarge, lose their pigments or become yellow or pale blue-green, and develop well-defined and somewhat thickened walls; these are called heterocysts. Except in the Chroococcales and Oscillatorineae, heterocysts are characteristically present in all the families of the blue-green algae. The terminal heterocysts (in Mastigocoleus and the Rivulariaceae) develop pores through one side-wall, and the intercalary heterocysts (in Scytonema, the Nostocaceae, and some species of Rivulariaceae) develop pores on both ends, or rarely (in *Brachy-*

trichia Quoyi) three pores on three sides. The wall is composed of two layers: the thickened inner layer of cellulose and the often delicate outer one of pectic substance. The shape, size, and number of heterocysts in a trichome are various according to species or even within a species.

The calyptra: The calyptra is a term used for the thickened outer wall of the apical cell of a trichome. The calyptra, also of importance in specific distinction, is seen only in the Oscillatoriaceae; and its shape is various according to species or even within a species.

The hormogone: The hormogone is a short length of a trichome with rounded ends and composed of vegetative cells which become separated by dead cells. Multiplication by hormogones is a chief method in the Oscillatoriales, especially in the marine species. In the Rivulariaceae and Stigonemataceae the hormogone is formed beneath the terminal hair. In the Oscillatoriaceae and Nostocaceae the formation is by fragmentation of the trichome; especially in the Nostocaceae the intercalary heterocysts help their separation. In the Scytonemataceae the hormogones are set free from the apical portions of the filaments and their branches.

The sporangium: This term is here restricted to Chamaesiphonaceae. The well-matured vegetative cells, generally the apical cells of the cushion plants, rarely solitary cells, are transformed in sporangia, which are usually larger in size or nearly spherical in shape as compared with the normal vegetative cells; and the whole or part of the protoplast divides successively or simultaneously to form endospores. The polyhedroidal endospores within a sporangium become spherical after liberation by the rupture of dissolution of the sporangial membrane. In the Nostocaceae the vegetative cells become sometimes thick-walled, but the protoplast never divides into spores as in the Chamaesiphonaceae.

The branching: In the Oscillatoriales the filament branches in two ways: true and false branching. True branching occurs only in the Stigonemataceae, while the Rivulariaceae, Scytonemataceae, and Oscillatoriaceae exhibit false branching. In Mastigocoleus a single cell divides in a plane parallel with the axis of the trichome and a branch issues laterally by successive divisions at right angles to those of the parent trichome. The newly formed branch secretes its own sheath. On the other hand, in addition to Mastigocoleus-like branching, other peculiar forms are seen in Brachytrichia. Setchell & Gardner (1919) removed Brachytrichia from the Rivulariaceae and placed it in the Stigonemataceae, for the reason that Brachytrichia is always truly branched. Another form of branching in the genus is as follows: a normal branch is formed first and a notch (V-shaped bend or loop) is developed below it (Iyengar & Desikachary 1954); or a V-shaped bend is formed first by the parent trichome and a branch occurs at the tip of the loop (Ercegović 1929, 29 a); and after loop-formation the apex of the loop breaks and the divided two arms develop into separate filaments. The former method being true branching, is called here Y-shaped branching; while the latter method, resulting in two separate trichomes is false

branching, referred to here as scytonematoid branching. The branching of Kyrtuthrix is only by loop-formation throughout the life of the plant, called here V-shaped branching.

In the Scytonemataceae and in some genera of Oscillatoriaceae (Lyngbya, Plectonema and Symploca) a single cell or a pair of cells, next to a heterocyst or degeneration cells, divides; and a single branch or a pair of branches, the tip cells of which divide continuously, issue through the side of the sheath.

In the Rivulariaceae and some species of Oscillatoriaceae the branching is due to growth of one broken part of a trichome, commonly in the former family, beneath an intercalary heterocyst. In the Rivulariaceae and in the thick-sheathed genera of Oscillatoriaceae the hormogones develop in situ within the sheath of the old filament and many branches issue from the open end of the old sheath.

2. Collection and preservation

All the specimens here examined, except some which were sent from my friends and colleagues, were collected by wading on rocky shores by myself, in many cases at the time of low spring tides. They were collected from all the coasts of Japan, from Hokkaido to the Amami Islands, during the fourteen years from 1947 to 1960. Lithophytic plants were gathered on rocks directly by hand; or such hard plants as *Kyrtuthrix maculans* and *Isactis plana* firmly adhering to rocks were taken by stripping them from the rocks with a knife or by breaking the rock with a chiesel. Plants epiphytic on large or small algae or even on Cyanophyta were collected together with the hosts. The old plants of Codium and Nemalion in which one or a few species sometimes grew were favorable hosts of endophytic plants. As the result of the growth of *Calothrix parasitica*, plants of *Nemalion vermiculare* and *N. multifidum* coloured deep blue-green, as if they were different algae, were sometimes found in these collections. Minute endophytic or epiphytic plants were unexpectedly discovered when the microscopical examination of other algae was progressing. In addition to planktonic species collected by nets, a number of species were found freely floating among filamentous algae. Most of mollusk shells and corals which were coloured blue-green had perforating species, mostly in association with one another.

Immediately after specimens were collected they were all fixed by the addition of an aqueous solution of 5–6 per cent formalin; the greater part of each was preserved as immersion specimens in glass-bottles; a smaller part of each was dried on paper and labelled. Immersion specimens require the addition of more formalin solution, generally once a year or two years, to prevent their drying. Examination and sketching have been done mostly by using the immersion specimens, which keep mostly the characteristics of the living condition.

All the specimens examined are deposited in the Herbarium, Department of Fisheries, Faculty of Agriculture, Kyoto University, Maizuru, and the Herbarium of Isamu Umezaki, Maizuru, although this fact is not indicated in the systematic part.

3. Taxonomy

Division **Cyanophyta**

Schussning, Verhandl. Zool.-Bot. Ges. Wien 74/75 : 259, 1924/25.

Class **Cyanophyceae**

Sachs, Lehrb. d. Bot. 4th ed., p. 248, 1874.

Myxophykea Wallroth, Fl. Crypt. Germ. 2: 4, 1833.
Myxophyceae Stizenberger, Rabenh. Alg. Sachsen, p. 18, 1860.
Phycochromaceae Rabenhorst, Fl. Eur. Algar. 1: 1, 1864.
Schizophyceae Cohn, Jahresber. Schles. Ges. Vaterl. Kultur 57 : 279, 1879.

Plant a single cell, a solitary trichome, a solitary filament or a microscopic or macroscopic globule, cushion, sphere, or layer (usually covered by a gelatinous sheath) composed of a group of coccoid cells (in the Chroococcales), or composed of a group of filaments (in the Oscillatoriales). Filaments (of Oscillatoriales) consisting of uni- or multiseriate chains of cells (trichomes) and a sheath extruded through the cell-membrane, simple or branched. Branching true or false. Sheaths composed of hyaline, gelatinous material, chiefly pectic or in some species hemicellulose, sometimes coloured, homogeneous or lamellate, firm or gelatinous or sometimes entirely diffluent. Trichomes uniseriate or multiseriate, each cell limited by a very thin cell membrane (or cell wall). Cells usually blue-green, spherical, cylindrical, or a modification of one of these shapes, surrounded by sheath material (in the Chroococcales) or by a very thin membrane (in the Oscillatoriales); protoplasm differentiated into a hyaline central region (central body or centroplasm), corresponding to a nucleus, but without nuclear membrane and nucleoli, not organized as in other plants, containing glycoproteids ; and a peripheral region (chromatic body or chromoplasm), containing chlorophyll a, carotinoids, xanthophyll, c-phycocyanin and c-phycoerythrin, not containing evident vacuoles. Cell division by fission ; in some families (Nostochineae) vegetative cells transform into sometimes slightly larger, well defined, somewhat thick-walled cells (heterocysts) with generally transparent cell contents. Reproduction by fragmentation of plant bodies (in the Chroococcales) and of trichomes (called hormogones, in the Oscillatoriales), by endospores formed in endosporangia which are transformed from vegetative cells (in the Chamaesiphonaceae), or rarely by spores (in some species of Rivulariaceae and Nostocaceae) which are transformed directly from vegetative cells ; sexual reproduction and flagellated spores unknown. Distribution all over the world, from arctic or antarctic to tropical regions. Habitats various, aquatic in fresh, brackish, marine and thermal waters, on rocks, wood, mud, or soil, or rarely on animals, aerial and subaerial, epiphytic on or endophytic in other plants, sometimes in many lichens, perforating calcareous rocks, shells, corals, and Corallinaceous algae. Some freshwater and terrestrial species fix atmospheric nitrogen.

Key to orders:

1. Plants uni- or multicellular, consisting of coccoid cells irregularly or regularly arranged within a gelatinous sheath; each cell separated by sheath-material; reproduction by fragmentation of plant bodies or endospores. ..... 1. *Chroococcales*
1. Plants multicellular and filamentous, consisting of uni- or multiseriate chains of cells (trichomes) or filaments; each cell separated from others by cross walls (cell membrane), cells sometimes transformed into heterocysts or spores; reproduction by hormogones or by spores..... ..... 2. *Oscillatoriales*

Order 1. **Chroococcales**

Wettstein, Handb. Syst. Bot. 3rd ed., p. 79, 1924.

Coccogoneae Thuret, Ann. Sci. Nat. VI. Bot. 1: 377, 1875. *Coccogonales* Atkinson, Coll. Text Book Bot. 2nd ed., p. 163, 1905.

Chamaesiphonales Wettstein, 1. c. 1924.

Entophysalidales Geitler, Beih. Bot. Centralbl. 41: 223, 1925.

Dermocarpales Geitler, 1. c. 1925.

Pleurocapsales Geitler, 1. c. 1925.

Plants uni- or multicellular, forming microscopic or macroscopic cushions or layers, invested by gelatinous sheaths (matrix); cells dividing each in two daughter-cells, separated by sheath material; reproduction by fragmentation of plant bodies or by endospores.

Key to families:

1. Plants consisting of nearly similar cells; cells divide in two equal daughter-cells; reproduction by fragmentation of plant bodies. ..... 1. *Chroococcaceae*
1. Plants consisting of upper coccoid and lower filamentous parts penetrating the substratum; cells divide in two equal or unequal daughter-cells; reproduction by endospores and by fragmentation of plant bodies. ..... 2. *Chamaesiphonaceae*

Family 1. **Chroococcaceae**

Naegeli, Gatt. Einzell. Alg., p. 44, 1849; Drouet & Daily, Butler Univ. Bot. Stud. 10: 220, 1952; 1. c. 12: 11, 1956.—Type genus: *Chroococcus* Naeg.

Plants uni- to multicellular, microscopic or macroscopic, various in shape and size, free floating or growing attached to various substrata; cells spherical, discoid, ovoid, cylindrical, or pyriform, each dividing in two cells of equal size and soon becoming separated from each other by sheaths of gelatinous material; reproduction by fragmentation.

Key to genera:

1. Cells before division ovoid to cylindrical, dividing in a plane perpendicular to the long axis... ..... 1. *Coccochloris*
1. Cells before division spherical, ovoid, cylindrical, or pyriform, never dividing in planes perpendicular to the long axis. 2
2. Cell division proceeding successively in three planes perpendicular to each other.. 2. *Anacystis*
2. Cell division proceeding successively in one or two planes perpendicular to each other..... 3

3. Plant long-cylindrical; cells dividing in one plane..... 3. *Johannesbaptistia*
3. Plant laminate or spherical; cells dividing in two planes..... 4
4. Plant laminate; cells arranged regularly in series of rows perpendicular to each other..... 4. *Agmenellum*
4. Plant spherical; cells arranged radially at the periphery of thallus..... 5. *Gomphosphaeria*

Genus 1. **Coccochloris**

Sprengel seq. Drouet & Daily, Butler Univ. Bot. Stud. 12: 13, 1956.—Type species: *C. stagnina* Spreng.

Plants microscopic or macroscopic, 1- to pluricellular; cells before division subspherical to cylindrical, later becoming ovoid or long-cylindrical, dividing always in one plane perpendicular to the long axis; gelatinous sheaths hyaline or later becoming yellow, homogeneous or lamellate.

One species:

Coccochloris stagnina Sprengel seq. Drouet & Daily, Butler Univ. Bot. Stud. 12: 15, figs. 145–163, 1956; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 414, 1956.

Plants aeruginous or dirty blue-green, microscopic or macroscopic, globular or irregular in shape, containing numerous cells; cells ovoid or ellipsoid, 3–5 μ in diameter, 1–2 times as long as the diameter; gelatinous sheaths hyaline, homogeneous, later often diffluent; protoplasm aeruginous, usually homogeneous. Pl. 1, fig. 1.

Habitat: Growing on rocks in the upper littoral belt, or floating among the filaments of Cladophora, Ectocarpus, and diatoms.

Amami Islands: Yamma, Sumiyo-mura, O-shima, *1747 a*, 8 Apr. 1955.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1624 c*, 30 Sept. 1954. *1928 c*, 5 Aug. 1955.

Shima Peninsula: Wagu, *698 b*, 9 Jun. 1952.

Amino: Amino Bay, Kyoto Pref., *779 b*, 24 Sept. 1952. *909 a*, 28 Oct. 1952. *1280 a*, 31 Aug. 1952.

Aomori Pref.: Asamushi near Aomori, *1193 a*, 9 Jul. 1953.

This minute alga has been found mostly floating among filamentous algae in rock depressions, sometimes in company with other species of Cyanophyta. The occurrence on the Japanese coast is rare as compared with other species, and it grows in summer or early autumn in Honshu, although on the Amami Islands it was found in April.

Geographical distribution: Cosmopolitan (on soil, rocks, and wood in aerial or subaerial stations, and in shallow fresh water, occasionally in brackish or marine waters, or floating in lakes and ponds).

Genus 2. **Anacystis**

Meneghini, Consp. Algol. Eugan., p. 324, 1837; Drouet & Daily, Butler Univ. Bot. Stud. 12: 34, 1956.—Type species: *A. marginata* Menegh.

Plants microscopic or macroscopic; cells after division hemispherical, later

becoming globular, dividing in three planes perpendicular to each other, irregularly or serially distributed within the gelatinous sheath; gelatinous sheaths hyaline or later becoming red, blue, or yellow.

Key to species of Anacystis:

1. Cells 8-50-75μ in diameter, usually remaining angular after division..... 1. *A. dimidiata*
1. Cells 6-15μ in diameter, soon becoming spherical after division..... 2. *A. aeruginosa*

1. **Anacystis dimidiata** (Kuetzing) Drouet & Daily, Butler Univ. Bot. Stud. 10: 221, 1952; 1. c. 12: 70, figs. 100-107, 1956.

Chroococcus turgidus Naegeli, Gatt. Einz. Alg., p. 46, 1849; Umezaki, Publ. Seto Mar. Biol. Lab. 2: 236, 1952; Mem. Coll. Agr., Kyoto Univ. 66: 63, pl. 1, fig. 1, 1953; Journ. Jap. Bot. 30: 57, 1955; Hirose, Biol. Journ. Okayama Univ. 3: 92, 1957.

Chroococcus turgidus var. *maximus* Nygaard pro synon. in Drouet & Daily, 1. c. 12: 71, 1956; Umezaki, Journ. Jap. Bot. 29: 172, fig. 36 A, 1954; 1. c. 30: 57, 1955.

Plants aeruginous, violet blue-green or olive-green, microscopic, 2-6-celled; cells after division becoming truncate-hemispherical, truncate-globular, or spherical, 8-50μ or 75μ in diameter, distributed without order or Eucapsoid-like within a gelatinous sheath; gelatinous sheaths hyaline, rarely pale blue, thin or very thick, up to 10μ in thickness, homogeneous or rarely lamellate; protoplasm aeruginous, violet blue-green, with fine or dense granules. Pl. 1, fig. 3.

Habitat: Growing among the filaments of Lyngbya, Hydrocoleum, and Calothrix, or free-floating in rock pools along high tide level.

Amami Islands: Koniya, O-shima, *1769 b*, *1784 b*, *1803 d*, *1808 b*, 9-11 Apr. 1955. Tean near Koniya, O-shima, *2224*, 28 Jun. 1958. Ikeji, Kikai-jima, *2381*, 6 Jul. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2030 c*, 25 May 1953. Tomioka, Amakusa, *2017 b*, 23 May 1956.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1545 a*, 24 Jun. 1954. *1615 c*, *1624 a*, *1628 c*, 30 Sept. 1954. *1659 b*, 8 Feb. 1955. *1930 b*, *1931 b*, 5 Aug. 1955. Shibukawa, Tamano, Okayama Pref., *1654 d*, 8 Feb. 1955. *1895 b*, 4 Aug. 1955. Tadano-umi, Hiroshima Pref., *301 d*, 8 Nov. 1950.

Kii Peninsula: Seto, Shirahama, *459 b*, 3 Aug. 1951. *537 c*, 1 Nov. 1951 (as *Chroococcus turgidus* by Umezaki, 1952 a).

Izu Peninsula: Nagatsuro near Cape Iro, *884 b*, 10 Oct. 1952.

Shima Peninsula: Oshima off Wagu, *622 c*, 12 Mar. 1952 (as *Chroococcus turgidus* by Umezaki, 1955 a). *734 c*, 10 Jun. 1952 (as *Chroococcus turgidus* by Umezaki, 1955 a). Wagu, *718 g*, 9 Jun. 1952 (as *Chroococcus turgidus* var. *maximus* by Umezaki, 1954, 55 a).

Wakasa Bay: Koiso, Maizuru Bay, *217 a*, 18 Aug. 1950. *666 b*, 23 May 1952. *1577 c*, 10 Aug. 1954. *1640 a*, 30 Nov. 1954. *1961 a*, 7 Nov. 1955. Ao-shima, Obama Bay, *92 b*, 22 Oct. 1949 (as *Chroococcus turgidus* by Umezaki, 1953 a).

Anacystis dimidiata, usually known as *Chroococcus turgidus* and var. *submarinus*, has been found mostly mingled among the plants of *Calothrix pilosa* and *C. crustacea* strata of which seem to be quite favorable for the growth of the alga.

The species, which has been reported under the name of *Chroococcus turgidus*, is common in fresh and thermal waters in Japan.

Geographical distribution: Cosmopolitan (in shallow fresh, brackish and marine waters or in seepage, often in plankton).

2. **Anacystis aeruginosa** (Zanardini) Drouet & Daily, Lloydia 11: 77, 1948; Butler Univ. Bot. Stud. 12: 76, figs. 108–113, 1956.

Aphanocapsa sesciacensis Frémy, Bull. Mus. Hist. Nat. Paris 34: 383, 1928; Mem. Soc. Nat. Sci. Nat. Math. de Cherbourg 41: 14, pl. 2, fig. 2, 1934; Umezaki, Journ. Jap. Bot. 28: 201, fig. 28 A, 1953; l. c. 30: 58, 1955.

Plants pale blue-green, microscopic or forming macroscopic gelatinous masses, expanded, up to several centimeters; cells after division becoming depressed-subspherical or spherical, 6–15μ in diameter, distributed without order or Eucapsoid-like within a gelatinous sheath; gelatinous sheaths hyaline, thin or thick, homogeneous or lamellate; protoplasm pale blue-green, homogeneous or sparsely fine-granular. Pl. 1, fig. 2.

Habitat: Growing on rocks in the upper littoral belt, or in the strata of *Calothrix scopulorum*.

Amami Islands: Koniya, O-shima, *1769 c*, 9 Apr. 1955. Ushuku, Kasari-mura, O-shima, *1857 b*, 13 Apr. 1955.

Shimonoseki: Yoshimi, *259*, 5 Nov. 1950.

Kii Peninsula: Seto, Shirahama, *395*, *405 a*, 21-22 May 1951. Kashima, Tanabe Bay, *461*, 2 Aug. 1951.

Shima Peninsula: O-shima off Wagu, *737 c*, 10 Jun. 1952 (as *Aphanocapsa sesciacensis* by Umezaki, 1953, 55 a).

Wakasa Bay: Ao-shima, Obama Bay, *563 b*, 10 Nov. 1951.

The plants of *Anacystis aeruginosa* collected were mostly very thick, gelatinous, widely expanded up to 10 cm.; and most of the cells were 10–15μ in diameter. This alga quite resembles the young solitary cells of *Entophysalis deusta* (*Pleurocapsa fuliginosa*-form); therefore attention is necessary when we do its specific determination. In *Anacystis aeruginosa* the gelatinous sheath is hyaline, homogeneous, whereas that of *Entophysalis deusta* is generally firm, distinct, and sometimes coloured light brown.

Geographical distribution: Cosmopolitan (on rocks, wood, large plants and attached animals in brackish and marine waters).

Genus 3. **Johannesbaptistia**

J. de Toni, Noter. Nomencl. Algol. 1: 6, 1934; Drouet & Daily, Butler Univ. Bot. Stud. 12: 84, 1956.

Cyanothrix Gardner, Mem. New York Bot. Gard. 7: 30, 1927.—Type species: *C. primaria* Gardn.

Plants microscopic, long-cylindrical, erect or curved; cells discoid (at apices depressed-spherical), uniseriate within a gelatinous sheath, dividing in only one plane along the diameter of the disc (perpendicular to the axis of the plant); gelatinous sheaths hyaline.

One species:

Johannesbaptistia pellucida (Dickie) W. R. Taylor & Drouet in Drouet, Bull. Torr. Bot. Club 65: 285, 1938; Taylor, Allan Hanc. Pac. Exp. 12: 124, 1945; Drouet & Daily, Butler Univ. Bot. Stud. 12: 85, figs. 182–184, 1956; Iyengar & Desikachary, Journ. Indian Bot. Soc. 25: 117, 1946.

Hormospora pellucida Dickie, Journ. Linn. Soc. Bot. 14: 365, 1874.

Cyanothrix primaria Gardner, Mem. New York Bot. Gard. 7: 30, pl. 6, fig. 57, 1927. *Johannesbaptistia primaria* J. de Toni, Noter. Nomencl. Algol. 1: 6, 1934; Drouet, Allan Hanc. Pac. Exp. 3: 16, pl. 2, figs. 3, 4, 1936.

Cyanothrix Willei Gardner, Mem. New York Bot. Gard. 7: 31, pl. 6, fig. 58, 1927. *Johannesbaptistia Willei* J. de Toni, Noter. Nomencl. Algol. 1: 6, 1934.

Nodularia? fusca W. R. Taylor, Carnegie Inst. Wash. Papers Tortugas Lab. 25: 48, pl. 1, fig. 23, 1928.

Plants aeruginous or olivaceous, erect or curved, up to 1 mm. in length, 12–18μ in diameter, at apices round; cells discoid or spherical discoid, 3–6μ in length, 7.5–10μ in diameter, uniseriate within a gelatinous sheath; gelatinous sheaths hyaline, 4–6μ in thickness, homogeneous or slightly lamellate, mucous, sometimes diffluent; protoplasm aeruginous, olivaceous, homogeneous. Pl. 1, fig. 4.

Japanese name: Ai-ribon (nom. nov.).

Habitat: Floating in rock pools along high tide level.

Amami Islands: Ikeji, Kikai-jima, *2379*, 6 Jul. 1958.

The short filaments in the present collection are usually erect, but the long ones, measuring nearly 1 mm. long, are curved, being intricated among other filamentous algae. The gelatinous sheaths are usually firm, smooth on their surfaces, but, sometimes, especially those of the matured long filaments are very mucous and diffluent. The cells are uniseriately arranged within the long-cylindrical, gelatinous sheath, discoid or spherical discoid in shape, and sometimes enveloped in a hyaline individual sheath, which, however, is usually diffluent, inconspicuous. The apical cell of the filament is sometimes round or sometimes conical in shape.

Johannesbaptistia pellucida, a new record for the Japanese marine flora, has been found only from the Amami Islands. The species is distributed in subtropical or tropical regions, although its occurrence is as yet rare in the world.

Geographical distribution: In shallow brackish, marine, or fresh waters. Mediterranean (Jugoslavia); Atlantic coast of North America (Massachusetts, Connecticut, Maryland, Florida); Atlantic Ocean (Bermuda); Pacific coast of North America (California, Mexico); West Indies (Puerto Rico, Bahamas, British West Indies, Virgin Islands); South America (Ecuador, Brazil); Southeast Asia (Indonesia); Indian Ocean (India); North Africa (Algeria).

Genus 4. **Agmenellum**

de Brébisson seq. Drouet & Daily, Butler Univ. Bot. Stud. 12: 86, 1956.—Type

species: *A. quadruplicatum* de Bréb.

Plants flat or foliose plate-shaped, microscopic or macroscopic; cells spherical, ovoid, or cylindrical, arranged in series of rows in two directions at right angles to each other; cell division proceeding successively in two planes perpendicular to each other and to the surface of the plate; gelatinous sheaths hyaline.

Key to species of Agmenellum:

1. Cells 3-4μ in diameter. ..... 1. *A. quadruplicatum*
1. Cells 4-7μ in diameter..... 2. *A. thermale*

1. **Agmenellum quadruplicatum** de Brébisson seq. Drouet & Daily, Butler Univ. Bot. Stud. 12: 86, fig. 133, 1956.

Merismopoedia glauca Kuetzing, Phyc. Germ., p. 142, 1845; Umezaki, Mem. Coll. Agr., Kyoto Univ. 66: 64, pl. 1, fig. 4, 1953.

Plants aeruginous, microscopic, rectangular, containing 2, 4, 6, 8, or 64 cells, up to 150μ in diameter; cells oval or spherical, 3–4μ in diameter, aggregated loosely or closely in the gelatinous sheath; gelatinous sheaths hyaline, mostly diffluent; protoplasm aeruginous, homogeneous. Pl. 1, fig. 5.

Habitat: Floating in rock depressions and rock pools in the supralittoral belt.

Wakasa Bay: Koiso, Maizuru Bay, *213 b*, *217 b*, 18 Aug. 1950 (as *Merismopoedia glauca* by Umezaki, 1953 a). *666 a*, 23 May 1952 (as *Merismopoedia glauca* by Umezaki, 1953 a). *2133*, 2 Jul. 1957.

The Japanese plant of *Agmenellum quadruplicatum* is the same as that of *Merismopoedia glauca* under which name it has been well known in fresh water and hot springs in Japan (Fukushima 1952; Hirose 1937; and Yoneda 1937, 53). The flat plant composed of numerous cells is easily broken by slight mechanical pressure, so it is mostly of 2-8-celled. The water in rock depressions or rock pools where the alga often grew was mixed marine water from sea and fresh water from heavy rains, thereby it being brackish in salinity.

Geographical distribution: Subcosmopolitan (in fresh, thermal and brackish waters, or rarely in marine water).

2. **Agmenellum thermale** (Kuetzing) Drouet & Daily, Butler Univ. Bot. Stud. 12: 89, figs. 134–142, 1956.

Merismopoedia thermalis Kuetzing, Phyc. Gener., p. 163, 1843.

Merismopoedia elegans A. Braun in Kuetzing, Spec. Algar., p. 472, 1849; Umezaki, Journ. Jap. Bot. 30: 58, 1955; Acta Phytota. Geobot. 16: 84, 1956.

Plants aeruginous, flat, rectangular, microscopic, later becoming membranaceous, expanded, containing numerous cells; cells 4–7μ in diameter, 5–9μ in length, after division globular, ovoid or spherical, distributed usually compactly in the gelatinous sheath; gelatinous sheaths hyaline, gelatinous, firm, or diffluent; protoplasm aeruginous, homogeneous or finely granular. Pl. 1, fig. 6.

Habitat: Growing among the filaments of other blue-green algae and brown

algae in rock depressions, in the supralittoral belt.

Amami Islands: Koniya, O-shima, *1802 a*, 11 Apr. 1955.

Kyushu: Tomioka, Amakusa, *2027 a*, 24 May 1956.

Shima Peninsula: Wagu, *800 c*, 4 Oct. 1952 (as *Merismopoedia elegans* by Umezaki, 1955 a).

Hokkaido: Oshoro, *1258 c*, 17 Jul. 1953 (as *Merismopoedia elegans* by Umezaki, 1956 a).

The Japanese plants are generally small in size, each consisting of up to one hundred cells; but there are rarely encountered large plants with several hundred cells. Because of its thin, flat, membranaceous body it is often seen broken in small pieces.

Geographical distribution: Cosmopolitan (in shallow fresh, brackish, or marine waters, or on mud).

Genus 5. **Gomphosphaeria**

Kuetzing seq. Drouet & Daily, Butler Univ. Bot. Stud. 10: 222, 1952; 1. c. 12: 93, 1956.—Type species: *G. aponina* Kuetz.

Plants microscopic, multicellular, spherical or ovoid, variously tubercular in shape, while dividing constricted; cells spherical, ovoid, cylindrical, or pyriform, arranged radially at the periphery of the plant; cell division proceeding successively in two planes perpendicular to each other; gelatinous sheaths hyaline, homogeneous; or individual sheaths about the cells often conspicuous and forming dichotomously branched structures extending radially towards the center of the gelatinous sheath.

One species:

Gomphosphaeria aponina Kuetzing seq. Drouet & Daily, Butler, Univ. Bot. Stud. 12: 98, figs. 178–180, 1956; Akatsuka, Suisan Gakujyutsu-shiryo 1: 6, pl. 7, fig. 11, 1951; Yoneda, Jap. Journ. Bot. 14: 111, 1953; Umezaki, Journ. Jap. Bot. 28: 363, fig. 34 A, 1953.

Plants aeruginous, spherical or ovoid, 40–80μ in diameter; cells clavate, pear- or heart-shaped while dividing, radially arranged in a matrix, pedicellate with radiating, short, thick, branched stalk, 4–7.5×6–12μ in size; protoplasm aeruginous, homogeneous or finely granular. Pl. 1, fig. 7.

Japanese name: Ai-no-tama (nom. nov.).

Habitat: Floating in rock pools along high tide level, sometimes in company with other plankton species.

Amami Islands: Ikeji, Kikai-jima, *2380*, 6 Jul. 1958.

Amino: Amino Bay, Kyoto Pref., *779 a*, 24. Sept. 1952. *905*, 28 Oct. 1952.

In September 1952 when I visited Amino Bay, Kyoto Prefecture, the alga grew very abundantly in rock pools along high tide level; but in October of the same year when I went there again, I did not collect such abundance as in the previous month, probably because the water had become too cold for the species. The alga from the Amami Islands was also found growing in such habitats as in that of Amino Bay; floating in rock pools along high tide level in which the water

was also hot due to strong sunshine when I collected it. Both the materials from Amino Bay and from the Amami Islands, only two localities on the Japanese coast for the species, are typical in all the characters. However, further exploration should produce it from other localities on the Japanese coast.

Yoneda (1953) reported this alga as occurring among submerged mosses in Oze, central Japan.

Geographical Distribution : Cosmopolitan (in fresh, brackish, and marine waters).

Family 2. **Chamaesiphonaceae**

Borzi, N. Giorn. Bot. Ital. 14 : 298, 1882 ; Drouet & Daily, Butler Univ. Bot. Stud. 10 : 222, 1952 ; 1. c. 12 : 100, 1956.—Type genus : *Chamaesiphon* A. Br. & Grun.

Plants uni- and multicellular ; cells spherical, ovoid, or cylindrical, basally attached to a substratum, dividing at first into daughter cells of unequal size and further developing (chiefly by cell divisions in planes parallel with the substratum) into cushions of radial structure, the basal cells often growing downwards into the substratum ; endosporangia formed from any cells which enlarge and divide internally, whole or in part, into a few or many endospores ; reproduction by fragmentation or by endospores.

One genus :

Genus 1. **Entophysalis**

Kuetzing, Phyc. Gener., p. 177, 1843 ; Drouet & Daily, Butler Univ. Bot. Stud. 12 : 101, 1956.—Type species : *E. granulosa* Kuetz.

Plants at first microscopic, later becoming macroscopic, growing on or within a substratum ; solitary cells various in shape ; cells of the cushions spherical, ellipsoidal, cylindrical, or polyhedroid, arranging in seriate, indistinctly radial or erect order ; cells of the filaments penetrating into the substratum cylindrical, hemispherical, spherical, ovoid, or polyhedroid ; endosporangia various in shape ; membrane of sporangium thin.

Key to species of Entophysalis :

1. Plants on rocks and on or in mollusk shells. ..... 1. *E. deusta*
1. Plants on or in larger algae. ..... 2. *E. conferta*

1. **Entophysalis deusta** (Meneghini) Drouet & Daily, Lloydia 11 : 79, 1948 ; Butler Univ. Bot. Stud. 12 : 103, figs. 185–194, 247–250, 1956 ; Umezaki, Publ. Seto Mar. Biol. Lab. 5 : 415, 1956.

Pleurocapsa fuliginosa Hauck, Rabenh. Krypt. Fl. 2 : 515, fig. 231, 1885 ; Umezaki, Journ. Jap. Bot. 28 : 201, fig. 28 B, 1953 ; 1. c. 30 : 58, 1955 ; Acta Phytotax. Geobot. 16 : 84, 1956.

Hyella caespitosa Bornet & Flahault, Journ. de Bot. 2 : 163, 1888 ; Umezaki, Journ. Jap. Bot. 29 : 172, fig. 36 C, 1954 ; 1. c. 30 : 59, 1955 ; Acta Phytotax. Geobot. 16 : 84, 1956.

Aphanocapsa litoralis Hansgirg pro synon. in Drouet & Daily, 1. c. 1956; Umezaki, Journ. Jap. Bot. 27: 219, fig. 18 B, 1952; Mem. Coll. Agr., Kyoto Univ. 66: 64, pl. 1, fig. 3, 1953; Acta Phytotax. Geobot. 16: 84, 1956. *Aphanocapsa litoralis* var. *macrococca* Hansgirg pro synon. in Drouet & Daily, 1. c. 1956; Umezaki, Journ. Jap. Bot. 27: 219, 1952; 1. c. 30: 58, 1955; Publ. Seto Mar. Biol. Lab. 2: 236, 1952.

Aphanocapsa concharum Hansgirg pro synon. in Drouet & Daily, 1. c. 1956; Umezaki, Journ. Jap. Bot. 30: 58, fig. 1 A, 1955.

Hyella Balanii Lehmann, Nyt Mag. Naturvid. 41: 85, pl. 2, figs. 1-11, 1903; Umezaki, Publ. Seto Mar. Biol. Lab. 2: 237, 1952.

Pleurocapsa minuta Geitler, Rabenh. Krypt. Fl. 14: 355, 1932; Umezaki, Publ. Seto Mar. Biol. Lab. 2: 237, 1952; Journ. Jap. Bot. 30: 58, 1955.

Plants microscopic or macroscopic, at first unicellular, later becoming olive-green, aeruginous, brown, violet, or reddish cushions; solitary cells spherical, ovoid, or pyriform, up to 20μ or rarely 30μ in diameter; cells of cushions spherical, after division chiefly polyhedroid, 3–6μ in diameter; cells of filaments penetrating into the substratum ovoid, spherical, cylindrical, or polyhedroid, usually uniseriate, or sometimes multiseriate, 2–15μ in diameter; endosporangia spherical or ovoid, up to 30μ or rarely more in diameter; gelatinous sheaths at first hyaline, later becoming brownish or lamellate; protoplasm aeruginous or violet, homogeneous. Pl. 2, fig. 1.

Habitat: Growing on rocks and concrete along high tide level, in the upper littoral or supralittoral belt, or perforating mollusk shells and corals, sometimes in company with *Mastigocoleus testarum*, *Plectonema terebrans* and *Gomontia polyrhiza*.

Amami Islands: Asani near Naze, O-shima, *1699 b*, 6 Apr. 1955. Naze, O-shima, *2168 b*, 24 Jun. 1958. Koniya, O-shima, *1752 b*, 9 Apr. 1955. *1839 b*, 11 Apr. 1955. Yamma, Sumiyo-mura, O-shima, *1747 b*, 8 Apr. 1955. Ushuku, Kasari-mura, O-shima, *2445*, 10 Jul. 1958. Tean near Koniya, O-shima, *2221*, *2229*, *2244*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2298*, 29 Jun. 1958. So-machi, Kikai-jima, *2398*, *2403*, 7 Jul. 1958. Kametsu, Tokuno-shima, *2529*, 17 Jul. 1958.

Kyushu: Cape Kaimon, Kagoshima Pref., *2057 a*, *2059 c*, 26 May 1956. Tomioka, Amakusa, *2018*, *2095 b*, 23 May 1956. Tsuyasaki, Fukuoka Pref., *1984 b*, 21 May 1956.

Shimonoseki: Yoshimi, *294 b*, 5 Nov. 1950.

Shikoku: Katsurahama, Kochi, *1403 e*, 17 Jun. 1954. Usa, Kochi Pref., *1415 b*, *1416 b*, *1425 b*, *1439 c*, 15-16 Jun. 1954.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1498 b*, 22 Jun. 1954. *1657 a*, 8 Feb. 1955. *1898 a*, 4 Aug. 1955. Ozuchi-jima off Tamano, Okayama Pref., *1514 b*, 23 Jun. 1954. Hon-jima, Shiaku Islands, *1622 a*, 30 Sept. 1954. *1935 b*, *1955 b*, 5 Aug. 1955. Tadano-umi, Hiroshima Pref., *298*, 8 Nov. 1950.

Kii Peninsula: Seto, Shirahama, *390 b*, 22 May 1951 (as *Aphanocapsa litoralis* var. *macrococca* by Umezaki, 1952 a). *408 b*, 22 May 1951 (as *Hyella Balanii* by Umezaki, 1952 a). *532 a*, 1 Nov. 1951. Yuzaki, Shirahama, *499 a*, 31 Oct. 1951 (as *Pleurocapsa minuta* by Umezaki, 1952 a). *503*, 31 Oct. 1951. Kashima, Tanabe Bay, *468 a*, 2 Aug. 1951 (as *Microcystis Reinboldii* by Umezaki, 1952 a).

Shima Peninsula: Goza, *590 b*, *596 c*, 11 Mar. 1952 (as *Aphanocapsa litoralis* var. *macrococca* by Umezaki, 1955 a). *750 c*, 11 Jun. 1952. Wagu, *611 a*, 11 Mar. 1952 (as *Pleurocapsa minuta* by Umezaki, 1955 a). O-shima off Wagu, *806 b* (as *Pleurocapsa minuta* by Umezaki, 1955 a), *821 d* (as

Aphanocapsa concharum by Umezaki, 1955 a), *824 e* (as *Hyella caespitosa* by Umezaki, 1954, 55 a), 5 Oct. 1952. Akogi-ura, Tsu, *678 b*, *680 b*, *693*, 7 Jun. 1953.

Izu Peninsula: Shimoda, *870*, 9 Oct. 1952 (as *Oncobyrsa adriatica* var. *micrococca* by Umezaki, 1953).

Enoshima: Enoshima, Kanagawa Pref., *1047*, *1050 a*, *1051 b*, 31 Mar. 1953.

Mi-ura Peninsula: Aburatsubo, *1009 b*, 29 Mar. 1953.

Boso Peninsula: Kominato, *1071*, 3 Apr. 1953 (as *Oncobyrsa adriatica* var. *micrococca* by Umezaki, 1953). Futomi, *1085 a*, 3 Apr. 1953. Mera, *1061 a*, *1063 b*, 2 Apr. 1953.

Matsushima Bay: Katsurashima, *1162 d*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *780 a*, 24 Sept. 1952. *1132 a*, *1134*, 13 Jun. 1953. *1271 a*, 31 Aug. 1953.

Wakasa Bay: Nagahama, Maizuru Bay, *1355*, 23 Oct. 1955. *1362*, 12 Nov. 1953. *1364 a*, 21 Nov. 1953. *1375*, 28 Dec. 1953. *1382 a*, 3 Feb. 1954. *2111 b*, 30 Jun. 1956. Koiso, Maizuru Bay, *1369 c*, 26 Nov. 1953. Sanbonmatsuhana, Maizuru Bay, *1964 a*, 7 Nov. 1955. Jya-jima, Maizuru Bay, *2112 a*, 2 Jul. 1956. Kato, Obama Bay, *419 b*, 21 Jun. 1951 (as *Aphanocapsa litoralis* by Umezaki, 1952, 53 a). Obama, Obama Bay, *109 c*, 10 Dec. 1949 (as *Pleurocapsa fuliginosa* by Umezaki, 1953). Kanagasaki, Tsuruga Bay, *220 c*, *225 c*, 29 Sept. 1950.

Hokkaido: Muroran, *1232*, 14 Jul. 1953. *1249 a*, 15 Jul. 1953 (as *Hyella caespitosa* by Umezaki, 1956 a). Oshoro, *1262 a*, 17 Jul. 1953 (as *Aphanocapsa litoralis* by Umezaki, 1956 a). Akkeshi, *1297 a*, 28 Jul. 1953. Rishiri-to, *1343 b*, 3 Aug. 1953.

Entophysalis deusta, a species of the coccoid blue-green algae revised by Drouet & Daily (1956), has numerous synonyms under which several Japanese plants have been reported by me. The species is commonly distributed on the Japanese coast, from the Amami Islands to Hokkaido. The plant like *Pleurocapsa fuliginosa* has sometimes large cells with a diameter of 30μ, which may be transformed into sporangia. In the cushion-shaped plant the surface cells are large and spherical, and are sometimes transformed into sporangia. The basal cells are generally elongate; they penetrate into the substratum. The endosporangia, usually larger than the vegetative cells, are spherical or ovoid in shape and contain numerous endospores, the liberation of which is probably performed by dissolution of the membrane of the sporangium or by dehiscing of the membrane as in *Entophysalis conferta*. Most reproduction seems to be done by endospores formed in the sporangium which is frequently formed in this species.

Geographical distribution: Cosmopolitan (on rocks, shells, wood, soil, and similar substrata or perforating mollusk shells or limestone or other rocks in marine or brackish waters).

2. **Entophysalis conferta** (Kuetzing) Drouet & Daily, Lloydia 11: 79, 1948; Butler Univ. Bot. Stud. 12: 111, figs. 196–215, 1956; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 415, 1956.

Dermocarpa prasina Bornet in Bornet & Thuret, Notes Algol. 2: 73, pl. 26, figs. 6-9, 1880; Umezaki, Journ. Jap. Bot. 29: 217, fig. 38, 1954.

Dermocarpa Leibleiniae Bornet in Bornet & Thuret, Notes Algol. 2: 73, pl. 26, figs. 3, 4,

1880; Umezaki, Journ. Jap. Bot. 25: 225, fig. 3, 1950.

Xenococcus Schousboei Thuret in Bornet & Thuret, Notes Algol. 2: 73, 75, pl. 26, figs. 1, 2, 1880; Holmes, Linn. Journ. Bot. 31: 257, 1895 (as *Dermocarpa Schousboei* Born.); Umezaki, Journ. Jap. Bot. 25: 225, fig. 2, 1950; l. c. 30: 59, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 65, 1953.

Oncobyrsa adriatica Hauck, Rabenh. Krypt. Fl. 2: 515, fig. 230, 1885; Okamura, Synopt. List Jap. Alg. 2nd ed., p. 266, 1916; Sorui Keito-gaku, p. 16, fig. 24, 1930; Nippon Kaiso-shi, p. 909, fig. 424, 1936; Inagaki, Shizen to Jinbun 2: 76, 1950; Umezaki, Publ. Seto Mar. Biol. Lab. 2: 237, 1952; Journ. Jap. Bot. 30: 58, 1955.

Xenococcus Chaetomorphae Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 436, pl. 36, figs. 2-4, 1918; Umezaki, Journ. Jap. Bot. 28: 202, fig. 29, 1953.

Dermocarpa sphaeroidea Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 440, pl. 36, fig. 7, 1918; Umezaki, Bot. Mag. Tokyo 68: 64, 1955.

Hyella socialis Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 443, pl. 36, fig. 5, 1918. *Myxohyella socialis* Geitler, Beih. Bot. Centralbl. 41: 246, 1925; Umezaki, Journ. Jap. Bot. 27: 220, fig. 21, 1952; l. c. 30: 59, 1955; Publ. Seto Mar. Biol. Lab. 2: 238, 1952; Bot. Mag. Tokyo 68: 63, 1955.

Dermocarpa protea Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 456, pl. 38, figs. 4, 5, 1918; Yamada & Tanaka, Month. Report Hokkaido Fish. Stat. 1: 166, 1934; Tokida, Bot. & Zool. 7: 522, fig. 1, 1930; Trans. Sapporo Nat. Hist. Soc. 15: 212, 1938; Umezaki, Mem. Coll. Agr., Kyoto Univ. 66: 66, pl. 1, fig. 9, 1953; Journ. Jap. Bot. 30: 59, 1955; Acta Phytotax. Geobot. 16: 85, 1956.

Dermocarpa sphaerica Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 457, pl. 39, fig. 14, 1918; Umezaki, Mem. Coll. Agr., Kyoto Univ. 66: 66, pl. 1, fig. 6, 1953; Bot. Mag. Tokyo 68: 64, 1955; Journ. Jap. Bot. 30: 59, 1955.

Xenococcus acervatus Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 459, pl. 31, fig. 13, 1918; Umezaki, Journ. Jap. Bot. 28: 202, fig. 28 C, 1953; l. c. 30: 59, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 64, pl. 1, fig. 5, 1953.

Xenococcus Gilkeyae Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 462, pl. 39, fig. 11, 1918; Umezaki, Journ. Jap. Bot. 27: 220, fig. 20, 1952; Publ. Seto Mar. Biol. Lab. 2: 237, 1952.

Xenococcus pyriformis Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 463, pl. 39, fig. 12, 1918; Umezaki, Journ. Jap. Bot. 25: 224, fig. 1, 1950; l. c. 30: 59, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 65, pl. 1, fig. 7, 1953; Acta Phytotax. Geobot. 16: 84, 1956.

Xenococcus Cladophorae Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 461, pl. 38, fig. 8, 1918; Umezaki, Acta Phytotax. Geobot. 16: 84, fig. 1 A, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957.

Chamaesiphon clavatus Setchell & Gardner, Proc. Calif. Acad. Sci. IV, 19: 118, pl. 4, fig. 1, 1930. *Dermocarpa clavata* Geitler, Rabenh. Krypt. Fl. 14: 406, fig. 235 & 1172, fig. 779, 1932; Umezaki, Journ. Jap. Bot. 28: 364, fig. 34 C, 1953; l. c. 30: 60, 1955.

Dermocarpella hemisphaerica Lemmermann pro synon. in Drouet & Daily, l. c. 1956; Umezaki, Journ. Jap. Bot. 28: 202, fig. 30 B, 1953; l. c. 30: 59, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 65, pl. 1, fig. 8, 1955.

Xenococcus laysanensis Lemmermann pro synon. in Drouet & Daily, l. c. 1956; Umezaki, Journ. Jap. Bot. 29: 172, fig. 36 B, 1954; l. c. 30: 59, 1955.

Plants epi- or endophytic, microscopic or macroscopic, at first unicellular, later becoming crustaceous strata, aeruginous, olive-green, or violet-green; solitary cells spherical, ovoid, or pyriform, 1–20μ or 30μ or sometimes more in diameter; cells of cushions spheroid, after division mostly spherical or polyhedroid, (1)–3–10μ in diameter; cells of filaments penetrating into substrata spherical, ovoid, cylindrical or polyhedroid, 3–8μ in diameter; endosporangia spherical, ovoid, cylindrical, pyriform or tubiform, up to 50μ in diameter; protoplasm aeruginous, olive-green or violet, homogeneous or finely granular. Pl. 2, fig. 2.

Habitat: Epiphytic on filamentous Cyanophyta (Lyngbya and Calothrix) and on larger algae (Gelidium, Pterocladia, Gymnogongrus, Caulacanthus, Myelophycus, Chaetomorpha, and Cladophora), or rarely endophytic in larger algae.

Amami Islands: Naze, O-shima, *1840 b*, *1842 b*, 12 Apr. 1955. *2161 b*, *2166*, *2175*, 24 Jun. 1958. Asani near Naze, O-shima, *1695 b*, *1700*, *1701 b*, *1707*, *1709*, 6 Apr. 1955. Yamm, Sumiyo-mura, O-shima, *1736 b*, *1742 b*, 8 Apr. 1955. Koniya, O-shima, *1756 c*, 9 Apr. 1955. Tean near Koniya, O-shima, *2231*, 28 Jun. 1958. Ankyaba, Kakeroma-to, *2339*, *2340*, 30 Jun. 1958. So-machi, Kikai-jima, *2391*, *2393*, 7 Jul. 1958. Kametsu, Tokuno-shima, *2533*, 14 Jul. 1958.

Tokara Islands: Nakano-shima, *1140 h*, E. Ogata, 5 Jun. 1953 (as *Dermocarpa sphaerica* by Umezaki, 1955). *1140 d*, E. Ogata, 5 Jun. 1953 (as *Dermocarpa sphaeroidea* by Umezaki, 1955).

Kyushu: Cape Kaimon, Kagoshima Pref., *2102*, *2106*, 26 May 1956. Ushinohama, Kago-shima Pref., *2051 d*, 25 May 1956. Aoshima, Miyazaki Pref., *2071 c*, *2085 b*, 27 May 1956. Hishiro, Oita Pref., *2088*, 28 May 1956. Tomioka, Amakusa, *2026*, *2093*, 22–23 May 1956.

Shimonoseki: Yoshimi, *260 b*, *263 b*, *269 c*, 5 Nov. 1950 (as *Xenococcus Gilkeyae* by Umezaki, 1952).

Shikoku: O-urasaki near Cape Ashizuri, *1469 a*, *1476 c*, *1478 b*, 19 Jun. 1954. Tsuro near Cape Ashizuri, *1489 b*, 20 Jun. 1954. Katsurahama, Kochi, *1402 d*, *1403 d*, *1404 f*, 17 Jun. 1954. Cape Muroto, *1455 b*, *1456 c*, *1458*, *1467*, 18 Jun. 1955. Usa, Kochi Pref., *1427 b*, 15 Jun. 1954.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1628 b*, 30 Sept. 1954. Ozuchi-jima off Tamano, Okayama Pref., *1684*, 10 Feb. 1955. Shibukawa, Tamano, Okayama Pref., *1649*, 8 Feb. 1955. *1896 b*, 4 Aug. 1955.

Awajishima: Yura, *1391*, *1397*, 13 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *380*, 21 May 1956. *458 b*, *463 c*, 3 Aug. 1951 (as *Xenococcus Gilkeyae* by Umezaki, 1952 a). Yuzaki, Shirahama, *496 c*, *497 d*, *498 b*, *501 b*, *509 b*, 31 Oct. 1951 (as *Xenococcus Gilkeyae* by Umezaki, 1952 a). Hatake-jima, Tanabe Bay, *467 c*, 2 Aug. 1951. Senjyojiki, Shirahama, *511 d*, 31 Oct. 1951.

Shima Peninsula: O-shima off Wagu, *614*, 12 Mar. 1952 (as *Dermocarpa protea* by Umezaki, 1955 a). *721 a*, *741*, 10 Jun. 1952 (as *Oncobyrsa adriatica* by Umezaki, 1955 *a*). *622 b*, 12 Mar. 1952 (as *Xenococcus pyriformis* and *X. Schousboei* by Umezaki, 1955 a). *815 c*, *823 c*, 5 Oct. 1952 (as *Xenococcus laysanensis* by Umezaki, 1952). *821 a*, *827 c*, 5 Oct. 1952 (as *Dermocarpa clavata*, *Dermocarpella hemisphaerica* and *Oncobyrsa adriatica* by Umezaki, 1955 a). Goza, *590 c*, 11 Mar. 1952 (as *Dermocarpa sphaerica* by Umezaki, 1955 a). *749 b*, 11 Jun. 1952. Wagu, *761*, 9 Jun. 1952 (as *Myxohyella socialis* by Umezaki, 1955 a). *793 a*, *797*, 4 Oct. 1952 (as *Dermocarpa protea* and *Dermocarpella hemisphaerica* by Umezaki, 1955 a). *991*, 31 Mar. 1953. Koshika, *607*, 11 Mar. 1952 (as *Dermocarpa clavata* by Umezaki, 1955 a).

Aichi Prefecture: Cape Irako, *343 a*, K. Inagaki, Jul. 1948 (as *Oncobyrsa adriatica* by Inagaki, 1950).

Enoshima: Enoshima, Kanagawa Pref., *990*, *991*, 31 Mar. 1953.

Izu Peninsula: Susaki near Shimoda, *840 b*, *899*, 8 Oct. 1952. Arashidomari near Shimoda, *836 b*, 8 Oct. 1952. Shimoda, *871 b*, 9 Oct. 1952. Nagatsuro near Cape Iro, *880 b*, *890*, 10 Oct. 1952.

Mi-ura Peninsula: Aburatsubo, *985*, 29 Mar. 1953 (as *Dermocarpa clavata* by Umezaki, 1953). Jyogashima, *987*, *1039 b*, 30 Mar. 1953 (as *Dermocarpa clavata* by Umezaki, 1953).

Boso Peninsula: Kominato, *1032 a*, *1034*, *1035*, *1036*, *1072 d*, *1075 c*, *1077 c*, *1080 c*, *1084*, 3 Apr. 1953. Futomi, *1027*, *1028*, 4 Apr. 1953. Mera, *994*, *1064*, 1-2 Apr. 1953.

Matsushima Bay: Katsura-shima, *1178*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *783*, *784*, *785*, *786 a*, *787*, 24 Sept. 1952 (as *Dermocarpa prasina* by Umezaki, 1954). *912*, 28 Oct. 1952 (as *Dermocarpa prasina* by Umezaki, 1954). *911*, 28 Oct. 1952 (as *Xenococcus Chaetomorphae* by Umezaki, 1953). *923*, 25 Nov. 1952. *930 c*, *932 b*, *933*, 25 Dec. 1952. *958*, *963*, 24 Feb. 1953. *977*, *980*, 19 Mar. 1953. *1108 b*, 23 Apr. 1953.

Wakasa Bay: Sanbonmatsuhana, Maizuru Bay, *65 c*, 25 Sept. 1949 (as *Dermocarpa sphaerica* by Umezaki, 1953 a). *133*, 3 Feb. 1950. *1379 b*, 12 Jan. 1954. *1578 a*, 10 Aug. 1954. *1582 b*, 25 Aug. 1954. *1641 c*, 30 Nov. 1954. *1963 c*, 7 Nov. 1955. Jyajima, Maizuru Bay, *487 b*, 23 Aug. 1951 (as *Xenococcus Gilkeyae* by Umezaki, 1952 and as *Dermocarpa sphaerica* by Umezaki, 1953 a). *488 b*, 8 Oct. 1951 (as *Dermocarpella hemisphaerica* by Umezaki, 1953 a). Koiso, Maizuru Bay, *132*, 3 Feb. 1950. *150*, 24 Apr. 1950. *417 c*, 8 Jun. 1951. *670*, *674 b*, 23 May 1952. Cape Bakuchi, Maizuru Bay, *2110 b*, 15 Jun. 1956. Nagahama, Maizuru Bay, *59 b*, 12 Sept. 1949 (as *Dermocarpella hemisphaerica* by Umezaki, 1953 a). *577*, 20 Feb. 1952 (as *Xenococcus pyriformis* by Umezaki, 1953 a). *1959 c*, 11 Aug. 1955. Kanmuri-jima off Maizuru Bay, *663*, 18 May 1952 (as *Dermocarpa protea* by Umezaki, 1953). Kato, Obama Bay, *319 b*, 16 Dec. 1950. *951*, 25 Jan. 1953. Takahama, Fukui Pref., *104*, 22 Nov. 1949 (as *Dermocarpa Leibleiniae* by Umezaki, 1950). *129 c*, 15 Jan. 1950 (as *Dermocarpa sphaerica* by Umezaki, 1953 a). *188*, 18 Jul. 1950. *1587 b*, 1 Sept. 1954. Tagarasu near Obama, *114 c*, 23 Dec. 1949 (as *Xenococcus acervatus* and *Dermocarpella hemisphaerica* by Umezaki, 1953 a).

Hokkaido: Muroran, *326*, 31 Aug. 1947 (as *Xenococcus pyriformis* by Umezaki, 1950, 56 a). *1221*, 14 Jul. 1953 (as *Xenococcus pyriformis* and *Dermocarpa protea* by Umezaki, 1956 a). Oshoro, *327*, 15 Jun. 1947 (as *Xenococcus minimus* by Umezaki, 1952, 56 a). *1261*, 17 Jul. 1953. Daikoku-jima, Akkeshi, *1298 c*, 28 Jul. 1953 (as *Dermocarpa protea* by Umezaki, 1956 a). Rebun-to, *1306*, 30 Jul. 1953 (as *Xenococcus pyriformis* by Umezaki, 1956 a). *1312*, 31 Jul. 1953. *1335*, 1 Aug. 1953.

Entophysalis conferta (Kuetz.) Dr. & Daily is a species in the coccoid Cyanophyta revised by Drouet & Daily (1956). On the Japanese coast it has been found on or in various algae and even various marine filamentous blue-green algae, forming crustaceous strata or as solitary cells. On filamentous Cyanophyta (mostly *Lyngbya semiplena*, *L. confervoides*, *L. lutea*, *Calothrix crustacea*, *C. pilosa*, and *C. scopulorum*) the plant grows mostly as solitary cells, spherical or ovoid in shape, exhibiting such forms as *Xenococcus Gilkeyae*, *X. acervatus*, *X. pyriformis*, *Dermocarpa sphaerica*, and *D. sphaeroidea* which have been described by Setchell & Gardner. The endophytic plant resembles *Hyella socialis* Setch. & Gardn. The plant on *Myelophycus caespitosus*, described as *Oncobyrsa adriatica* (named "Iwahige-no-kobu" in Japanese by K. Inagaki, 1950), has been well known among Japanese phycologists since its report by K.

Okamura from Enoshima in 1916. In addition to Oncobyrsa-like plants, various solitary or crustaceous plants have been found growing on *Myelophycus caespitosus*. On the host plant, J. Tokida (1930, 38) discovered the plants described as *Dermocarpa protea*. I have also found this on the same brown alga from Shima Peninsula. After being well matured the vegetative cells of the plant are sometimes transformed into endosporangia in which numerous, small, spherical endospores are formed by successive or simultaneous divisions. In addition to endospores the fragmentation of vegetative plants seems to be a method of the reproduction for the species.

Geographical distribution: Cosmopolitan (epiphytic on or endophytic in larger algae in marine and brackish waters).

Order 2. **Oscillatoriales**

Copeland, Ann. New York Acad. Sci. 36: 78, 1936; Smith, Fresh-water Alg. of United States, 2nd ed., p. 572, 1950.

Hormogoneae Thuret, Ann. Sci. Nat. VI. Bot. 1: 377, 1875. *Hormogonales* Atkinson, Coll. Text Book, 2nd ed., p. 163, 1905.

Gloeosiphonales Wettstein, Handb. Syst. Bot., 3rd ed., p. 80, 1924.

Nostocales Geitler, Beih. Bot. Centralbl. 41: 252, 1925.

Stigonematales Geitler, l.c. 1925.

Plant multicellular, a solitary trichome or a solitary filament, in variously shaped strata of many trichomes or many filaments; or a group of filaments, usually enclosed in a gelatinous sheath, forming a microscopic or macroscopic cushion, sphere, or layer; filaments branched or unbranched; branching false or true; trichomes uniseriate or multiseriate, straight, arcuate, or spirally or irregularly twisted, of the same diameter throughout or attenuate towards both ends, or attenuate from base to apex, with or without a sheath; sheaths enclosing single or many trichomes, homogeneous or lamellate, firm or mucous, hyaline or coloured; vegetative cells more or less alike in shape, spherical, ellipsoidal, discoid, or cylindrical; each cell separated from its neighbor by a cell membrane, sometimes differentiating into a heterocyst or a spore; heterocysts basal or intercalary; reproduction by hormogones or by spores.

Key to suborders:

1. Trichomes uniseriate, unbranched; cells alike, differentiated into neither hair cells nor heterocysts; reproduction by hormogones..... 1. *Oscillatorineae*
1. Trichomes uni- or multiseriate, branched or unbranched; cells sometimes differentiated into hair cells, spores, or heterocysts; reproduction by hormogones or by spores... 2. *Nostochineae*

Suborder 1. **Oscillatorineae**

Smith, Fresh-water Alg. of United States, 2nd ed., p. 573, 1950.

Trichomes uniseriate, unbranched, cylindrical or slightly attenuate at the apices, straight, flexuous, twisted in a regular spiral or irregularly contorted; sheaths present or absent, enclosing one or more trichomes, firm or gelatinous or diffluent, hyaline

or coloured, homogeneous or lamellate; both heterocysts and spores absent; reproduction by hormogones.

One family:

Family **Oscillatoriaceae**

Kirchner in Engler & Prantl, Natürl. Pflanzenfam., I, 1 a, p. 61, 1898; Drouet, Cyan. in Smith's Man. of Phyc., p. 165, 1951.—Type genus: *Oscillatoria* Vauch.

Plant a single filament, layer, or cushion; filaments unbranched or rarely false-branched; sheaths variable, present or absent, firm or gelatinous or diffluent, hyaline or coloured, homogeneous or lamellate; trichomes uniseriate, straight, arcuate, more or less uncinate at the apices, or spirally twisted, one or many within a sheath, cylindrical or slightly attenuate at the apices; cells all similar in shape and function; growth throughout; both heterocysts and spores absent; reproduction by hormogones.

Key to genera:

Tribe I. **Vaginarieae.** Trichomes vaginate, one or many within a sheath; sheaths in many species blackish, yellow, red, or blue.

Subtribe 1. Trichomes one to several, rarely many within a sheath, more or less loosely aggregate; sheaths hyaline, lamellate in many species.

1. Sheaths firm, lamellate, hyaline or coloured; trichomes few within a sheath; apical cells rarely capitate; cells never very short ..... 1. *Schizothrix*

1. Sheaths more or less mucous, sometimes diffluent, hyaline; trichomes few within a sheath; apical cell in most species capitate; cells never longer than diameter, in several species exceedingly short. ..... 2. *Hydrocoleum*

Subtribe 2. Trichomes numerous within a sheath, closely or irregularly congested; sheaths always hyaline, rarely lamellate.

1. Plants spherical in shape; trichomes irregularly curved, more or less loosely enclosed within a sheath ..... 3. *Sphaeronema*

1. Plants filamentous in shape; trichomes straight, closely crowded within a sheath 2

2. Filaments subdichotomously branched; sheaths firm or hardly diffluent ..... 4. *Sirocoleum*

2. Filaments simple or dispersely branched; sheaths more or less mucous, often diffluent. ..... 5. *Microcoleus*

Tribe II. **Lyngbyeae.** Trichomes evaginate or vaginate, solitary within a sheath; sheaths rarely blackish, yellow, sometimes red, never colouring blue.

Subtribe 1. **Lyngbyinae.** Filaments simple or branched; sheaths firm, usually hyaline, rarely becoming brown; apex of trichome straight, curved, or spiraled.

1. Filaments abundantly branched; branching often geminate ..... 6. *Plectonema*

1. Filaments unbranched or sparsely branched; branching solitary 2

2. Filaments simple, free, entangled in a floccose or pannose stratum, especially caespitose. ..... 7. *Lyngbya*

2. Filaments ascending from a repent base and joined in fascicles, often branched ..... 8. *Symploca*

Subtribe 2. **Oscillarinae.** Filaments simple; sheaths thin, always hyaline, mucous, more or less diffluent, absent in many species or not apparent; trichomes in some species curving at the apex.

1. Sheath present..... 9. *Phormidium*
1. Sheath absent..... 2
2. Trichomes twisted in a spiral throughout their length..... 3
2. Trichomes straight, flexuous, or twisted in an irregular spiral at the apices..... 4
3. Cross walls distinct..... 10. *Arthrospira*
3. Cross walls obscure..... 11. *Spirulina*
4. Trichomes free..... 12. *Oscillatoria*
4. Trichomes aggregated in a fascicle..... 13. *Skujaella*

Tribe 1. **Vaginarieae**

Gomont, Journ. de Bot. 4: 351, 1890; Ann. Sci. Nat. VII. Bot. 15: 290, 1892.

Trichomes vaginate, two or several within a sheath; sheaths in many species blackish, yellow, red, or blue.

Genus 1. **Schizothrix**

Kuetzing, Phyc. Gener., p. 230, 1843; Gomont, Ann. Sci. Nat. VII. Bot. 15: 292, 1892. —Type species: *S. fuscescens* Kuetz.

Plants cushion-shaped, often encrusted with calcium carbonate; filaments erect, prostrate, or in wavy fascicles, often trunk-like below, above spreading, false-branched or simple; sheaths hyaline, dark yellow, red or purple, firm, lamellate, the apices acuminate; trichomes few within a sheath, somewhat loosely aggregate, the apices straight, usually attenuate; cells often longer than the diameter, never much shorter; apical cell capitate, the outer membrane rarely thickened.

One species:

Schizothrix lacustris A. Braun in Kuetzing, Spec. Algar., p. 320, 1849; Tab. Phyc., II, p. 11, tab. 39, fig. V; Gomont, Ann. Sci. Nat. VII. Bot. 15: 301, pl. 6, figs. 9–12, 1892; Umezaki, Journ. Jap. Bot. 27: 222, fig. 24, 1952; Publ. Seto Mar. Biol. Lab. 2: 248, 1952.

Plants crustaceous, dirty blue-green; filaments irregularly flexuous, densely intricate, below narrow and trunk-like, above spreading and repeatedly branched; branches intricate or nearly parallel, generally short; sheaths hyaline, ample, generally wide at the basal portion; trichomes pale blue-green, 1–1.5 μ in diameter, several within a sheath at the basal or middle portion of filaments, but sparse or single in branches; cross walls constricted, pellucid, not granulate; cells up to 4μ in length, quadrate or 2–3 times as long as the diameter; protoplasm homogeneous; apical cell round. Pl. 3, fig. 1.

Habitat: Growing on mollusks and rocks in the littoral belt, usually in company with Cladophora and Lyngbya.

Shikoku: Tsuro near Cape Ashizuri, *1485 b*, 20 Jun. 1954.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1620 d*, 30 Sept. 1954.

Kii Peninsula: Seto, Shirahama, *385*, 23 May 1951.

Wakasa Bay: Nagahama, Sanbonmatsuhana, and Koiso, Maizuru Bay, *493 a*, 9 Oct. 1951.

778 b, 16 Sept. 1952. *965 b*, 2 Mar. 1953. *1130 b*, 27 May 1953. *1358 b*, 4 Nov. 1953. *1377 b*, 12 Jan. 1954. *1576 b*, 22 Jul. 1954. *2552*, 3 Oct. 1958.

Schizothrix lacustris, belonging to Gomont's subgenus Inactis, grows mostly in fresh water or rarely in marine water. The Japanese specimen, which should be referred to the var. *caespitosa*, has been found abundantly mostly on mollusk shells and rarely on rocks, frequently in company with Cladophora and *Lyngbya semiplena*, never forming pure strata.

Geographical distribution: In fresh water pools or lakes, or in marine water. Atlantic coast of Europe (Germany); Mediterranean (France); Pacific coast of North America (Alaska); Pacific Ocean (Marshall Islands, New Zealand).

Genus 2. **Hydrocoleum**

Kuetzing, Phyc. Gener., p. 196, 1843; Gomont, Ann. Sci. Nat. VII. Bot. 15: 332, 1892. —Type species: *H. homoeotrichum* Kuetz.

Plants caespitose or cushion-shaped, very rarely encrusted with calcium carbonate, or Phormidium-like; filaments more or less false-branched; sheaths always hyaline, somewhat amorphous or later entirely diffluent; trichomes few within a sheath, often loosely aggregate, apices straight, rarely attenuate; cells generally shorter than the diameter, in some species extremely short; apical cell capitate, the outer membrane with a thickened calyptra.

Key to species of Hydrocoleum:

1. Plants endophytic in Codium 2
1. Plants not endophytic in Codium 3
2. Trichomes 2.5-4μ in diameter ..... 1. *H. confluens*
2. Trichomes 5-7μ in diameter ..... 2. *H. coccineum*
3. Trichomes 8-16μ in diameter ..... 3. *H. lyngbyaceum*
3. Trichomes 14-24μ in diameter 4
4. Plants mucous; trichomes 14-21μ in diameter ..... 4. *H. glutinosum*
4. Plants caespitose; trichomes 18-24μ in diameter ..... 5. *H. cantharidosmum*

1. **Hydrocoleum confluens** (Setchell & Gardner) Drouet, Field Mus. Nat. Hist. Bot. Ser. 20: 134, 1942.

Microcoleus confluens Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 471, pl. 40, fig. 25, 1918.

Hydrocoleum codicola Setchell & Gardner, Proc. Calif. Acad. Sci. IV, 12: 701, pl. 12, fig. 3, 1924; Umezaki, Journ. Jap. Bot. 28: 365, fig. 35 B, 1953; 1. c. 30: 213, 1955.

Plants endophytic in Codium, solitary or more or less loosely aggregate; filaments erect or somewhat flexuous, blue-green; sheaths hyaline, homogeneous, gelatinous, moderately ample, irregular on the surface, distinct at first, later diffluent; trichomes 1–8 or more within a sheath, 2.5–4μ in diameter, separate or loosely entwined, the apices straight, slightly attenuate; cross walls not constricted, not granulate; cells 1.3–5μ in length, 0.5–1.5 times as long as the diameter; protoplasm homogeneous;

apical cell moderately round or somewhat elongate, with slightly thickened outermembrane. Pl. 3, fig. 2.

Japanese name: Miru-onawamo (Umezaki 1955 a).

Habitat: Growing among the utricles of Codium (*C. intricatum*, *C. fragile*, and *C. adhaerens*).

Amami Islands: Ankyaba, Kakeroma-to, *2492*, 30 Jun. 1958. Kasari, O-shima, *2256*, Y. Yoneda, *2263*, Y. Yoneda, 10 Jul. 1958.

Kyushu: Tomioka, Amakusa, *2099 b*, 23 May 1956.

Shikoku: Tsuro near Cape Ashizuri, *1486*, 20 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1688 b*, 9 Feb. 1955. Hon-jima, Shiaku Islands, *1958 b*, 6 Aug. 1955.

Kii Peninsula: Seto, Shirahama, *411 a*, 22 May 1951.

Shima Peninsula: O-shima off Wagu, *1120*, 9 Jun. 1952 (as *Hydrocoleum codicola* by Umezaki, 1955 a).

Izu Peninsula: Arashidomari near Shimoda, *895*, 8 Oct. 1952 (as *Hydrocoleum codicola* by Umezaki, 1953).

Matsushima Bay: Yogasaki, *1149*, M. Kurogi, 21 Dec. 1951. Katsura-shima, *1175*, *1181*, 8 Jul. 1953.

Dr. Drouet has written me that he examined my Japanese specimens (nos. 895, 1181) and he had concluded that *Hydrocoleum codicola* Setch. & Gardn. is the same as *Hydrocoleum confluens* (Setch. & Gardn.) Dr. Therefore, in accordance with Dr. Drouet's opinion, I have determined the Japanese specimen endophytic in Codium, which had been referred to *Hydrocoleum codicola* by me, as *H. confluens*. The specimen of *Microcoleus confluens* Setch. & Gardn., which was removed to Hydrocoleum by Dr. Drouet (1. c.), was found forming a spongy stratum in company with other Cyanophycean species on rocks at Lands End, San Francisco, California. On the other hand, the type plant of *Hydrocoleum codicola* Setch. & Gardn. was found growing among the utricles of Codium plants on San Marcos Island, Gulf of California.

Geographical distribution: On rocks and in Codium in marine water. Pacific coast of North America (California, Mexico).

2. **Hydrocoleum coccineum** Gomont, Ann. Sci. Nat. VII. Bot. 15: 342, pl. 13, figs. 1, 2, 1892; Umezaki, Journ. Jap. Bot. 29: 220, fig. 39 E, 1954; Publ. Seto Mar. Biol. Lab. 5: 426, 1956.

Plants endophytic in Codium; filaments elongate, somewhat flexuous, sparsely branched; sheaths hyaline, cylindrical, slightly gelatinous; trichomes bluish-violet or purple, single or several within a sheath and loosely entwined, parallel, 5–6–(7)μ in diameter, apices slightly attenuate; cross walls not constricted, not granulate; cells 2–6μ in length; protoplasm homogeneous or finely granular; apical cell round, capitate, without calyptra. Pl. 3, fig. 3.

Japanese name: Miru-tsuki (nom. nov.).

Habitat: Growing among the utricles of Codium (*C. adhaerens*, *C. intricatum*, and *C. fragile*).

Amami Islands: Asani near Naze, O-shima, *1710*, 6 Apr. 1955. Koniya, O-shima, *1835*, 11 Apr. 1955. Ankyaba, Kakeroma-to, *2478*, *2479*, *2491*, 14 Jul. 1958. Ushuku, Kasari-mura, O-shima, *1878*, 13 Apr. 1955. Kasari, O-shima, *2262*, Y. Yoneda, 11 Jul. 1958. Akakina, Kasari-mura, O-shima, *2528*, 12 Jul. 1958. Gusuku, Sumiyo-mura, O-shima, *1734*, 7 Apr. 1955.

Enoshima: Enoshima, Kanagawa Pref., *989 a*, 31 Mar. 1953.

Izu Peninsula: Arashidomari near Shimoda, *897*, 8 Oct. 1952.

Hydrocoleum coccineum was found very abundantly on the Amami Islands, growing in Codium plants, rarely in company with *Brachytrichia Quoyi* and *Hydrocoleum confluens*. The trichomes are usually bluish-violet or purple in colour, and they are more broader than those of *H. confluens* which the alga resembles well.

Geographical distribution: In Codium. Mediterranean (France); Pacific Ocean (Marshall Islands).

3. **Hydrocoleum lyngbyaceum** Kuetzing, Spec. Algar., p. 259, 1849; Tab. Phyc., I, p. 37, tab. 51, fig. 1; Gomont, Ann. Sci. Nat. VII. Bot. 15: 337, pl. 12, figs. 8–10, 1892; Umezaki, Journ. Jap. Bot. 26: 269, fig. 16, 1951; 1. c. 30: 212, 1955; Publ. Seto Mar. Biol. Lab. 2: 248, 1952; 1. c. 5: 425, 1956; Mem. Coll. Agr., Kyoto Univ. 66: 73, pl. 5, fig. 7, 1953; Bot. Mag. Tokyo 68: 70, 1955; Acta Phytotax. Geobot. 16: 89, 1956.

Plants dark green, mucous, smooth, compact, widely expanded; filaments unbranched below, above abundantly branched; sheaths hyaline, thick, irregular on the surface, the apices acuminate or open, sometimes entirely diffluent; trichomes dark or yellowish-green, numerous at the base of filament and contorted into loose spirals, 8–16μ, mostly 9–11μ in diameter, the apices slightly attenuate; cross walls not constricted, mostly granulate; cells 2.3–4μ in length, 1/3–1/6 as short as the diameter; apical cell with a thickened watch-glass-like calyptra. Pl. 3, fig. 4.

Japanese name: O-nawamo (Umezaki 1955 a).

Var. **lyngbyaceum**

Plants caespitose, generally epiphytic; sheaths firm.

Var. **rupestre** Kuetzing seq. Gomont, 1. c. 1892.

Plants expanded, mucous; sheaths entirely diffluent.

Habitat: Growing on rocks in the upper or lower littoral belt, rarely in the supralittoral belt, or epiphytic on larger algae (Corallina, Hypnea, Gelidium, Ulva, and Cladophora).

Amami Islands: Koniya, O-shima, *1803 a*, *1824 b*, 11 Apr. 1955. Tean near Koniya, O-shima, *2232*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2289*, *2290*, 29 Jun. 1958. Naze, O-shima, *2160 b*, 24 Jun. 1958. Kasari, O-shima, *2278*, *2446*, *2452*, *2462*, 11 Jul. 1958. Ushuku, Kasari-mura, O-shima, *1855 a*, 13 Apr. 1955. *2438*, 10 Jul. 1958. Akakina, Kasari-mura, O-shima, *1866 c*, 13 Apr. 1955. Yamma, Sumiyo-mura, O-shima, *1747 c*, 12 Apr. 1955. Ankyaba, Kakeroma-to, *2319*, *2333*, *2471*, 30 Jun. 1958. Ikeji, Kikai-jima, *2353*, 6 Jul. 1958. So-machi, Kikai-jima, *2385*, *2395*, *2397*, 7 Jul. 1958. Kametsu, Tokuno-shima, *2512*, *2544*, 14 Jul. 1958.

Tokara Islands: Takara-jima, *1139 f*, E. Ogata, 27 May 1953.

Kyushu : Ushinohama, Kagoshima Pref., *2029 b*, 25 May 1956. Aoshima, Miyazaki Pref., *2075 b*, *2077 b*, *2079 a*, 27 May 1956. Tsuyasaki, Fukuoka Pref., *1984 c*, *1988 b*, 21 May 1956.

Shimonoseki : Yoshimi, *252 b*, *254 b*, *257 b*, 5 Nov. 1950.

Shikoku : Usa, Kochi Pref., *1426 a*, *1430 b*, *1432 b*, *1440 c*, *1442 b*, 16 Jun. 1954.

Seto Inland Sea : Ozuchi-jima off Tamano, Okayama Pref., *1522 a*, 23 Jun. 1954. *1593 d*, 29 Sept. 1954. *1682 b*, 10 Feb. 1955. *1909 b*, 5 Aug. 1955. Hon-jima, Shiaku Islands, *1550 a*, *1556 b*, *1564 c*, 24 Jun. 1954. *1624 b*, *1630 a*, 30 Sept. 1954. *1930 c*, *1945 b*, 5 Aug. 1955. Tadano-umi, Hiroshima Pref., *302 a*, *303 b*, *304 b*, 8 Nov. 1950.

Awajishima : Yura, *1394 b*, *1395 b*, 13 Jun. 1954.

Kii Peninsula : Seto, Shirahama, *374 b*, *391 b*, 22 May 1951, *443 a*, 3 Aug. 1951. *532 b*, 1 Nov. 1951. Senjyojiki, Shirahama, *511 a*, 31 Oct. 1951. Kashima, Tanabe Bay, *468 b*, 2 Aug. 1951. Hatake-jima, Tanabe Bay, *470 b*, 2 Aug. 1951.

Shima Peninsula : Akogi-ura, Tsu, *685 c*, *687 a*, 7 Jun. 1952. O-shima off Wagu, *724 b*, *738 b*, 10 Jun. 1952. *819 a*, *824 b*, *827 a*, 5 Oct. 1952. Wagu, *696 b*, *703c* , *705 a*, 9 Jun. 1952.

Izu Peninsula : Ebisujima near Shimoda, *849*, 8 Oct. 1952. Nagatsuro near Cape Iro, *882*, 10 Oct. 1952.

Mi-ura Peninsula : Aburatsubo, *1016*, *1037 a*, 29 Mar. 1953.

Boso Peninsula : Kominato, *1078 b*, 3 Apr. 1953. Futomi, *1029*, 4 Apr. 1953.

Matsushima Bay : Katsura-shima, *1158 b*, *1161 b*, *1162 a*, 8 Jul. 1953.

Wakasa Bay : Kanmuri-jima off Maizuru Bay, *658*, 18 May 1952. *2114 b*, 10 Oct. 1956. Koiso and Nagahama, Maizuru Bay, *70*, 26 Sept. 1949. *131*, 3 Feb. 1950. *244*, 25 Oct. 1950. *310 a*, *312*, 17 Nov. 1950, *345*, *346 b*, 31 Jan. 1951. *489*, 9 Oct. 1951. Kato, Obama Bay, *355 b*, 1 Feb. 1951. Tagarasu near Obama, *115 a*, 23 Dec. 1949. Suizu, Tsuruga Bay, *771 b*, 27 Jul. 1952.

Hokkaido : Oshoro, *1252 b*, *1253 g*, 17 Jul. 1953. Hariusu near Otaru, *324 b*, 31 Aug. 1947. Muroran, *325 b*, 22 Jul. 1947.

Hydrocoleum lyngbyaceum, a truly marine and cosmopolitan species in distribution, has been found at all localities I visited, occurring throughout the year, mostly on rocks (var. *rupestre*) and rarely epiphytic on other plants (var. *lyngbyaceum*). The alga has been found mostly associated with other filamentous species : *Hydrocoleum cantharidosmum*, *H. glutinosum*, *Microcoleus chthonoplastes*, *M. tenerrimus*, *Lyngbya aestuarii*, *L. semiplena*, *Calothrix pilosa*, and *C. crustacea*. The majority of the specimens collected have the trichomes of a diameter of 9–11μ.

Geographical distribution : Cosmopolitan (on rocks and larger algae and plants, or on mud in marine water).

4. **Hydrocoleum glutinosum** (Agardh) Gomont, Ann. Sci. Nat. VII. Bot. 15 : 339, 1892 ; Umezaki, Journ. Jap. Bot. 28 : 266, fig. 35 C, 1953 ; l. c. 30 : 212, 1955 ; Publ. Seto Mar. Biol. Lab. 5 : 426, 1956.

Plants dark yellowish-green or dirty blue-green, mucous, not caespitose, usually widely expanded or cylindrical in shape ; sheaths hyaline, very irregular on the surface, very mucous, occasionally entirely diffluent ; trichomes pale or dark green, 14–21μ, generally 17–19μ in diameter, the apices attenuate truncate ; cross walls not constricted, granular ; cells 2.5–4–(5)μ in length, 1/3–1/6 as short as the diameter ;

protoplasm granular; apical cell with calyptra. Pl. 3, fig. 5.

Japanese name: Nebari-nawamo (nom. nov.).

Habitat: Growing on rocks in the lower or upper littoral belt, sometimes associated with other Hydrocoleum, Microcoleus, and Lyngbya.

Amami Islands: Koniya, O-shima, *1814*, 11 Apr. 1955. Tean near Koniya, O-shima, *2225*, 28 Jun. 1958. Yamma, Sumiyo-mura, O-shima, *1745 a*, *1750 a*, 8 Apr. 1955. Naze, O-shima, *1851*, 12 Apr. 1955. Sakihara, Kasari-mura, O-shima, *2464*, 11 Jun. 1958. Ushuku, Kasari-mura, O-shima, *2439*, 10 Jun. 1958. Ikeji, Kikai-jima, *2351*, *2358*, *2366*, 6 Jul. 1958. Wan, Kikai-jima, *2409*, *2410*, *2416*, 8 Jul. 1958. Kametsu, Tokuno-shima, *2474*, *2505*, *2509*, 14 Jul. 1958.

Kyushu: Shingu, Fukuoka Pref., *1971 b*, 20 May 1956.

Shimonoseki: Yoshimi, *266 a*, 5 Nov. 1950.

Shikoku: Usa, Kochi Pref., *1429 a*, *1430 a*, *1431 a*, 15 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1593 e*, *1594 c*, 29 Sept. 1954.

Kii Peninsula: Seto, Shirahama, *406 a*, 22 May 1951. *443 b*, 3 Aug. 1951. Senjyojiki, Shirahama, *511 b*, 31 Oct. 1951. Hatake-jima, Tanabe Bay, *464 a*, 2 Aug. 1951.

Shima Peninsula: Goza, *593 b*, *598 a*, 11 Mar. 1952.

Kinosaki: Hiyoriyama near Kinosaki, Hyogo Pref., *2123*, 11 Nov. 1956.

Wakasa Bay: Koiso, Maizuru Bay, *29*, 22 Oct. 1949. *1361*, 5 Nov. 1953. *1367*, 26 Nov. 1953. Kato, Obama Bay, *15*, 22 Jun. 1949. *322*, 16 Dec. 1950.

Although the plant of *Hydrocoleum lyngbyaceum* is gelatinous, it is not so mucous as that of *H. glutinosum* in which the sheaths are entirely diffluent so their trichomes are not enclosed in the sheath but mostly dispersed separately. In many cases even under slight pressure we can not see an entire filament under the microscope because the sheath is very soft and gelatinous.

Since *H. glutinosum* has been found on the warmer coasts south of the Shima Peninsula and south of Wakasa Bay, central part of Honshu along the Pacific coast and the Japan Sea coast respectively, it seems to be most suited for growth in warmer water. On the contrary, both *H. cantharidosmum* and *H. lyngbyaceum* have been found widely distributed on nearly all the coasts of Japan.

Geographical distribution: Subcosmopolitan (on rocks, mud, or larger algae in marine water).

5. **Hydrocoleum cantharidosmum** (Montagne) Gomont, Journ. de Bot. 4: 353, 1890; Ann. Sci. Nat. VII. Bot. 15: 336, pl. 12, figs. 6, 7, 1892; Umezaki, Journ. Jap. Bot. 28: 238, fig. 32 A, 1953; 1. c. 30: 212, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 73, pl. 5, fig. 6, 1953; Publ. Seto Mar. Biol. Lab. 2: 248, 1952; 1. c. 5: 425, 1956; Bot. Mag. Tokyo 68: 70, 1955.

Plants olive or dark blue-green, caespitose, up to 1 cm. in length; filaments nearly straight, sparsely branched; sheaths hyaline, very thick, sometimes twice as thick as the trichome, rough on the surface, here and there lamellate, mucous, sometimes diffluent; trichomes blue-green, (16)–18–24–(28)μ in diameter, few within a sheath, nearly parallel or loosely entwined, solitary in the upper portion of filament, the apices slightly attenuate or not, truncate; cross walls not constricted, granulate or

not; cells (2)-2.5-4.5μ in length, 1/5-1/9 (sometimes 1/11) as short as the diameter; protoplasm finely granular; apical cell calyptrate. Pl. 4, fig. 1.

Japanese name: Futo-onawamo (Umezaki 1955 a)

Habitat: Growing on rocks in the upper littoral belt, rarely in the lower littoral or supralittoral belt, or rarely epipytic on larger algae (Ulva and Dictyota).

Amami Islands: Asani near Naze, O-shima, *1706 a*, 6 Apr. 1955. Koniya, O-shima, *1758 b*, *1763 b*, *1769*, *1773*, *1783 a*, *1789*, *1805*, *1811*, *1820*, *1822 b*, 9-11 Apr. 1955. Tean near Koniya, O-shima, *2188*, *2190*, *2235*, *2236*, *2237*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2208*, *2291*, *2293*, *2300*, 29 Jun. 1958. Ankyaba, Kakeroma-to, *2320*, *2336*, *2496*, 30 Jun. 1958. Gusuku, Sumiyo-mura, O-shima, *1726 a*, 7 Apr. 1955. Urasokari near Koniya, *2540*, Y. Yoneda, 1 Jul. 1958. Sakihara, Kasari-mura, O-shima, *2457*, *2466*, *2537*, 11 Jul. 1958. Ikeji, Kikai-jima, *2365*, 6 Jul. 1958. Wan, Kikai-jima, *2419*, 8 Jul. 1958. Kametsu, Tokuno-shima, *2484*, *2485*, *2489*, *2504*, *2515*, *2522*, 14 Jul. 1958.

Tokara Islands: Takara-jima, *1139 b*, E. Ogata, 27 May 1953.

Kyushu: Shingu and Tsuyasaki, Fukuoka Pref., *1969 a*, *1970*, *1971 a*, *1972*, *1987*, *1993*, *1995*, *1996*, 20-21 May 1956.

Shimonoseki: Yoshimi, *261 a*, *288*, *290 a*, *292*, *294 a*, 5 Nov. 1950.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1512*, *1513*, 23 Jun. 1954. Honjima, Shiaku Islands, *1536 b*, *1555 a*, *1565 b*, 23-24 Jun. 1954. *1622 c*, 30 Sept. 1954. *1672 c*, 9 Feb. 1955. *1928 a*, *1933 b*, *1934 b*, *1945 a*, *1946 b*, 5 Aug. 1955.

Kii Peninsula: Seto, Shirahama, *151*, Y. Yoneda, May 1950. *374 a*, *381 b*, *387*, *391 a*, *393 b*, *396*, *404*, 22 May 1951. Yuzaki, Shirahama, *2690*, 8 Jun. 1960.

Shima Peninsula: O-shima off Wagu, *724 c*, *728 a*, *734 a*, 10 Jun. 1952. *824 a*, 5 Oct. 1952.

Boso Peninsula: Futomi, *1099*, 4 Apr. 1953.

Matsushima Bay: Katsura-shima, *1165*, *1170*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *1279*, 31 Aug. 1953.

Wakasa Bay: Koiso, Maizuru Bay, *30*, 22 Oct. 1949. *665*, 23 May 1952. *1125*, 19 May 1953. Takahama, Fukui Pref., *1123*, 13 May 1953. Kato, Obama Bay, *16*, 22 Jun. 1949. *26*, 28 Jun. 1949. *151*, 6 May 1950. *418*, *421*, *422 b*, 21 Jun. 1951. *561 b*, 10 Nov. 1951. Tsunekami, Cape Tsunekami, *483 b*, 8 Aug. 1951.

Hokkaido: Oshoro, *1254 d*, 16 Jul. 1953.

Hydrocoleum cantharidosmum, which is distributed throughout tropical or subtropical regions, has also commonly been found on the Japanese coast; while in such northern, colder regions as Matsushima Bay and Hokkaido the growth is poor and rare in occurrence. The plants form caespitose strata by itself or more frequently are associated with other filamentous species (*Hydrocoleum glutinosum*, *H. lyngbyaceum*, *Lyngbya aestuarii*, *Calothrix crustacea*, and others) on rocks in the littoral belt, mostly in the upper littoral belt.

The trichomes of this species are mostly 18-24μ in diameter, but I have sometimes found the large trichomes with a diameter of 28-35μ (my specimens, nos. 2485 and 2522) which have the typical characters for the species; but these plants do not belong to *H. Holdenii* Tilden, which has usually greater trichomatal dimensions, 24-35 (usually 25-30)μ and a more thicker hemispherical outer wall of the apical cell,

according to Tilden (1910) and Drouet (1938).

Geographical distribution: On rocks and algae in marine water. Atlantic Ocean (Canary Islands); Pacific coast of North America (Mexico); Central America (Costa Rica); West Indies (Guadeloupe, St. Croix, Barbados, Puerto Rico); Pacific Ocean (New Caledonia, Marshall Islands, Hawaiian Islands, Society Islands); Australia (South Australia); Southeast Asia (Indonesia, Philippines); Indian Ocean (Ceylon).

Genus 3. **Sphaeronema** Umezaki, gen. nov.

Planta sphaerica, minuta; trichomatibus intra mucosum stratum numerosis, brevis vel longis, enormiter curvatis, ad apices haud attenuatis, ad genicula constrictis; vaginae diffluentes; cellulis subsphaericis aut diametro brevioribus; cellula apicalis rotundata; calyptra nulla.

This microscopic plant is nearly spherical, growing solitary or confluent with others on rocks, rarely perforating calcareous rocks. The trichomes, which are long or short and torulose, are irregularly curved without order in a rounded, hyaline or light brown, gelatinous sheath.

The new genus Sphaeronema undoubtedly belongs to Gomont's tribe Vaginarieae; the trichome is not provided with a discrete sheath, although a rounded gelatinous sheath in which numerous trichomes are enclosed is present.

One species:

Sphaeronema lithophila (Ercegović) Umezaki, comb. nov.

Isocystis lithophila Ercegović, Rad. Jugosl. Acad. 244: 160, pl. 7, fig. 4, 1932.

Plants spherical, 30–200μ in diameter, light brown; trichomes numerous in a hyaline or light brown, mucous, homogeneous, gelatinous sheath, short or long, irregularly curved; cross walls constricted; cells nearly spherical or a little shorter than the diameter, 1–2μ in diameter; protoplasm homogeneous, pale blue-green; apical cell round, neither capitate nor calyptrate. Pl. 10, fig. 11.

Habitat: Growing on rocks and concrete in the upper littoral belt.

Kyushu: Cape Kaimon, Kagoshima Pref., *2059 d*, 26 May 1956.

Shima Seninsula: Goza, on rocks in the upper littoral belt, with *Entophysalis deusta*, *590 d*, 11 Mar. 1952 (Syntype).

Mi-ura Peninsula: Aburatsubo, *1009 a*, 29 Mar. 1953.

Boso Peninsula: Mera, *1061 b*, 2 Apr. 1953.

Isocystis lithophila Erceg., which grew in calcareous rocks, was published as a new species of Isocystis from the Dalmatian coast of Jugoslavia by Ercegović (1932); he placed it in the Nostocaceae, all the genera of which possess heterocysts. Afterwards, Frémy (1934) removed it to the Oscillatoriaceae. I agree with Frémy's opinion concerning its systematic position and think that its position is in Gomont's Vaginarieae.

On the Japanese coast this minute alga has sometimes been found growing on

the surfaces of rocks or concrete, never perforating calcareous rocks as did the type material of *Isocystis lithophila* as described by Ercegović.

I have written to Dr. Ercegović for the loan of the type specimen of *I. lithophila* and have asked his opinion on my specimen (no. 590 d) which was sent to him. Kindly, he has answered me that although the type specimen was destroyed during the war my Japanese specimen is quite similar to the original material as far as he could remember. So I have designated my specimen (no. 590 d) as the syntype to serve as the type of this species.

Isocystis lithophila does not belong to the genus Isocystis in which the trichome end attenuates; therefore the species is placed in the new genus Sphaeronema.

Geographical distribution: On rocks or perforating calcareous rocks in marine water. Mediterranean (Adriatic Sea).

Genus 4. **Sirocoleum**

Kuetzing, Spec. Algar., p. 259, 1849; Gomont, Ann. Sci. Nat. VII. Bot. 15: 347, 1892. —Type species: *S. guyanense* Kuetz.

Plants caespitose; filaments elongate, fruticulose, dichotomously branched; sheaths firm or slightly diffluent, never coloured, cylindrical, not lamellate; trichomes numerous within a sheath, often aggregate into many fascicles, the apices straight; apical cell conical, never capitate.

One species:

Sirocoleum Kurzii (Zeller) Gomont, Ann. Sci. Nat. VII. Bot. 15: 349, pl. 14, figs. 3, 4, 1892; Drouet, Field Mus. Nat. Hist. Bot. Ser. 20: 116, 1942.

Microcoleus Weeksii Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 470, pl. 40, fig. 24, 1918.

Hydrocoleum Boergesenii Gardner, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Isl. 8: 289, 1932. *Microcoleus Boergesenii* Frémy, Dansk Bot. Arkiv. 9: 12, fig. 1, 1939; Umezaki, Journ. Jap. Bot. 27: 119, fig. 17 G, 1952; l. c. 30: 212, 1955; Publ. Seto Mar. Biol. Lab. 2: 246, 1952; Acta Phytotax. Geobot. 16: 89, 1956.

Plants solitary or caespitose, dirty blue-green; filaments moderately long, up to 0.5 mm. long, up to 50μ or 80μ in diameter, sometimes irregularly or dichotomously branched; sheaths hyaline, thick, gelatinous, homogeneous, smooth or rough on the surface, the apices closed and acuminate or open; trichomes pale blue-green, 5.5–7μ in diameter, numerous or sparse within a sheath, usually densely or sometimes loosely intertwined, the apices attenuate or rarely not; cross walls not constricted, not granulate; cells short, 1.5–3μ in length, 1/2–1/4 as short as the diameter; protoplasm homogeneous or finely granular; apical cell long- or obtuse-conical, or round, without calyptra. Pl. 4, fig. 2.

Japanese name: Edauchi-nawamo (nom. nov.).

Habitat: Growing scattered among various algae (Gelidium, Corallina, Sphacelaria, Cladophora, Ulva, and others).

Kyushu : Tomioka, Amakusa, *2000 b*, *2002 a*, 22 May 1956.

Kii Peninsula : Seto, Shirahama, *379*, 21 May 1951 (as *Microcoleus Boergesenii* by Umezaki, 1952 a).

Shima Peninsula : O-shima off Wagu, *826 b*, 5 Oct. 1952 (as *Microcoleus Boergesenii* by Umezaki, 1955 a). Wagu, *706 b*, *763*, *764 a*, 9 Jun. 1952 (as *Microcoleus Boergesenii* by Umezaki, 1955 a).

Amino : Amino Bay, Kyoto Pref., *1104*, 23 Apr. 1953.

Mi-ura Peninsula : Sendagasaki, Yokosuka Bay, *996*, 28 Mar. 1953. Aburatsubo, *1003*, 29 Mar. 1953.

Hokkaido : Muroran, *323 a*, 31 Aug. 1947 (as *Microcoleus Boergesenii* by Umezaki, 1956 a).

I have examined the type specimen of *Microcoleus Weeksii* Setch. & Gardn., which is preserved in the California Academy of Science, San Francisco, through the courtesy of Dr. Howell, and ascertained that it is identical with *Sirocoleum Kurzii* (Zeller) Gom. *Microcoleus Weeksii* was collected by Mrs. J. M. Weeks (February 1, 1896) near Pacific Gorve, California, and described by Gardner (1918) as new. Gardner (1932) described a new species *Hydrocoleum Boergesenii*, on the basis of a collection of Dr. Boergesen at Christiansstedt's Lagoon, St. Croix, West Indies, to which *Microcolens Weeksii* and *Sirocoleum Kurzii* are quite similar when judging from their descriptions. Frémy (1939) removed *Hydrocoleum Boergesenii* to Microcoleus and named it *M. Boergesenii* (Gardn.) Frémy. Although the type of *Hydrocoleum Boergesenii* has not been available for this study I have combined it with *Sirocoleum Kurzii*.

In 1942 Dr. Drouet examined the type specimen of *Microcoleus Weeksii* Setch. & Gardn. and identified it as *Sirocoleum Kurzii*. Dr. Drouet also has the same opinion as me on the point that *Hydrocoleum Boergesenii* Gardn. is identical with *Sirocoleum Kurzii*. Hence, under the species *S. Kurzii* both *Hydrocoleum Boergsenii* and *Microcoleus Weeksii* are placed here as synonyms.

Geographical distribution : On rocks and other algae in marine water. Atlantic coast of Europe (France); North Africa (Algeria); Indian Ocean (India); Atlantic coast of North America (Florida); Pacific coast of North America (California); West Indies (St. Croix).

Genus 5. **Microcoleus**

Desmazières, Catalog. Plant. Botanogr. Belgique, p. 7, 1823; Gomont, Ann. Sc. Nat. VII. Bot. 15 : 350, 1892.—Type species : *M. terrestris* Desmaz.

Plants endophytic in Codium or lithophytic on rocks, solitary or forming a widely expanded stratum; filaments simple, vaguely branched; sheaths hyaline, more or less cylindrical, never lamellate, in many species finally diffluent; trichomes many within a sheath, closely crowded, often funiform and contorted, the apices straight, attenuate; apical cell acute, rarely obtuse-conical.

Key to species of Microcoleus :

1. Plants endophytic in Codium 2

1. Plants not endophytic in Codium 3
2. Trichomes 1.2μ in diameter; apical cell round. ..... 1. *M. Wuitneri*
2. Trichomes (1.2)–1.5–1.8–(2)μ in diameter; apical cell sharp conical ..... 2. *M. Voukii*
3. Trichomes 0.6–1μ in diameter ..... 3. *M. sanctae-crucis*
3. Trichomes 1.5–6μ in diameter. 4
4. Trichomes 1.5–2μ in diameter; apical cell very acute-conical. ..... 4. *M. tenerrimus*
4. Trichomes 2.5–6μ in diameter; apical cell more or less attenuate ..... 5. *M. chthonoplastes*

1. **Microcoleus Wuitneri** Frémy, Compt. Rend. Acad. Sci. Paris 195: 1413, 1932; Frémy, Mém. Soc. Nat. Sci. Nat. Math. de Cherbourg 41: 68, pl. 18, fig. 1, 1934.

Plants endophytic in Codium; filaments elongate, simple, nearly straight or slightly undulate, up to 30μ in diameter; sheaths hyaline, almost diffluent; trichomes pale blue-green, elongate, loosely aggregate, numerous within a sheath, ca. 1.2μ in diameter, the apices not attenuate; cross walls not constricted, not granulate, somewhat pellucid; cells longer than the diameter, 2.5–4.6μ in length; protoplasm subhomogeneous; apical cell round, without calyptra. Pl. 4, fig. 3.

Habitat: Growing among the utricles of *Codium adhaerens*, in company with *Hydrocoleum confluens*.

Enoshima: Enoshima, Kanagawa Pref., *989 b*, 31 Mar. 1953.

On the basis of specimens collected at Banyuls, France by Feldmann, Frémy (1932) described several noteworthy species endophytic in Codium, of which one, *M. Wuitneri*, was found in *Codium difforme*. In the type specimen the colour of the trichome is rose, according to the diagnosis; whereas in the Japanese specimen, which was found growing in *Codium adhaerens*, in company with *Hydrocoleum confluens*, the colour is pale blue-green, though other characteristics are typical.

Geographical distribution: Endophytic in Codium. Mediterranean (France); Atlantic Ocean (Canary Islands).

2. **Microcoleus Voukii** Frémy, Compt. Rend. Acad. Sci. Paris 195: 1414, 1932; Frémy, Mém. Soc. Nat. Sci. Nat. Math. de Cherbourg 41: 70, pl. 18, fig. 3, 1934; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 425, 1956.

Plants endophytic in Codium; filaments long, usually simple, nearly straight, rarely branched; sheaths hyaline, mostly diffluent; trichomes violet, rose, or pale blue-green, long, numerous within a sheath, densely aggregate, (1.2)–1.5–1.8–(2)μ in diameter, the apices generally attenuate; cross walls not constricted, not granulate, often pellucid; cells 3–9.3μ in length, 2–5 times as long as the diameter; protoplasm homogeneous or sometimes granular; apical cell sharp conical. Pl. 4, fig. 4.

Habitat: Growing among the utricles of Codium (*C. fragile*, *C. divaricatum*, and *C. intricatum*), sometimes in company with *Calothrix codicola* and *Hydrocoleum confluens*.

Amami Islands: Naze, O-shima, *2200*, *2204*, 24 Jun. 1958. Gusuku, Sumiyo-mura, O-shima, *1732*, 7 Apr. 1955. Kasari, O-shima, *2255*, 10 Jul. 1958.

Kyushu: Cape Kaimon, Kagoshima Pref., *2101*, *2103*, *2108*, 26 May 1956. Tomioka, Ama-

kusa, *2097*, *2098*, *2099 a*, 23 May 1956.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1527*, 23 Jun. 1954.

Wakasa Bay: Takahama, Fukui Pref., *1373 b*, *1374 b*, 1 Dec. 1953.

The type specimen of *Microcoleus Voukii* was collected at Banyuls, France by Feldmann and briefly described as new by Frémy (1932). Frémy (1934) published a detailed diagnosis and figure for the species in his "Les Cyanophycées des côtes d'Europe" and distinguished it from *Microcoleus tenerrimus*, to which it is most closely related, in having the trichome coloured violet-rose and in not being constricted at the cross walls. However, in the Japanese specimens the colour of the trichome is variable, some specimens being violet-rose and others pale blue-green.

Geographical distribution: Endophytic in Codium. Mediterranean (France).

3. **Microcoleus sanctae-crucis** Frémy, Dansk Bot. Arkiv. 9: 17, fig. 2, 1939.

Plants solitary among other algae; filaments elongate, straight or irregularly curved, sometimes attenuate towards the apices, mostly 10–20μ in diameter, simple, rarely branched; sheaths hyaline, sometimes diffluent; trichomes pale blue-green, 0.6–0.8μ or 1μ in diameter, numerous within a sheath, the apices not attenuate; cross walls not constricted, usually obscure, not granulate; cells 2.5–3μ in length, 2–5 times as long as the diameter; protoplasm homogeneous; apical cell round, neither capitate nor calyptrate. Pl. 4, fig. 5.

Habitat: Growing in the stratum of *Microcoleus chthonoplastes* and *Hydrocoleum glutinosum*, in the lower littoral belt.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1593 a*, *1594 a*, 29 Sept. 1954.

Frémy (1939) reported a minute alga, *Microcoleus sanctae-crucis*, in his "Cyanophycées marines des anciennes Antilles Danoises", which dealt with the marine Cyanophyceae of the Danish West Indies collected by F. Boergesen. The original material was found among and under plants of *Scytonema velutinum*. The Japanese alga was found dispersed in strata of *Hydrocoleum glutinosum*, *Microcoleus chthonoplastes*, and others. Most of the filaments are 10–20μ in diameter, and their apices are sometimes attenuate like those of *Microcoleus tenerrimus*. The trichomes are 0.6–0.8μ, rarely 1μ in diameter, generally a little slender than those of the original diagnosis in which the diameter is described to be mostly 0.8μ and rarely 1μ. The cells of the material at hand are 2.5–3μ in length, being on an average nearly equal in length. According to the original description, however, the length is variable, from 1μ to 4μ. As mentioned above, there seem to be some differences between the Japanese specimen and the type although the latter has not been examined by me; the specific determination has been made with some hesitation.

Geographical distribution: On rocks in marine water. West Indies (St. Croix, Bonaire Island).

4. **Microcoleus tenerrimus** Gomont, Ann. Sci. Nat. VII. Bot. 15: 355, pl. 14, figs. 9–11, 1892; Umezaki, Journ. Jap. Bot. 27: 119, fig. 17 F, 1952; l. c. 30: 212,

1955 ; Publ. Seto Mar. Biol. Lab. 2 : 247, 1952 ; 1. c. 5 : 424, 1956 ; Mem. Coll. Agr., Kyoto Univ. 66 : 72, pl. 5, fig. 5, 1953 ; Bot. Mag. Tokyo 68 : 69, 1955 ; Acta Phytotax. Geobot. 16 : 89, 1956.

Microcoleus tenerrimus var. *longus* Umezaki, Seto Mar. Biol. Lab. 2 : 247, fig. 3, 1952.

Plants densely matted, blue-green layers, or mixed with other algae ; filaments simple or sparsely branched ; sheaths hyaline, thick, rough on the surface, apices acuminate or open, occasionally diffluent ; trichomes pale blue-green or olive-green, moderately numerous within a sheath, but when young sparse, elongate, flexuous, generally loosely entwined, 1.5–2μ in diameter, apices long-attenuate ; cross walls constricted, generally pellucid, without granules ; cells 2–6μ or rarely more in length, up to 3 times as long as the diameter ; protoplasm sometimes finely granular ; apical cell very acute-conical, not capitate. Pl. 5, fig. 1.

Japanese name : Hoso-konawamo (Umezaki 1955 a).

Habitat : Growing on rocks in the upper littoral belt, usually associated with other Microcoleus, Hydrocoleum, Lyngbya, and Calothrix.

Amami Islands : Asani near Naze, O-shima, *1711*, 6 Apr. 1955. Naze, O-shima, *2160 a*, 24 Jun. 1958. Yamma, Sumiyo-mura, O-shima, *1738 a*, *1750 d*, 8 Apr. 1955. Koniya, O-shima, *1803 c*, *1806 c*, *1815 b*, 11 Apr. 1955. Ushuku, Kasari-mura, O-shima, *1855 c*, 13 Apr. 1955. *2434*, 10 Jul. 1958. Akakina, Kasari-mura, O-shima, *1866 b*, *1870 d*, 13 Apr. 1955. Tean near Koniya, O-shima, *2222*, 28 Jun. 1958.

Tokara Islands : Nakano-shima, *1140 b*, E. Ogata, 5 Jun. 1953.

Kyushu : Ushinohama, Kagoshima Pref., *2031 b*, *2032 b*, *2050 a*, 25 May 1956. Ao-shima, Miyazaki Pref., *2077 a*, *2083 b*, 27 May 1956. Tomioka, Amakusa, *2002 c*, 22 May 1956.

Shimonoseki : Yoshimi, *272 b*, 5 Nov. 1950.

Seto Inland Sea : Ozuchi-jima off Tamano, Okayama Pref., *1593 b*, 29 Sept. 1954.

Kii Peninsula : Seto, Shirahama, associated with *Hydrocoleum cantharidosmum* and *H. lyngbyaceum* on rocks, *391 d*, 22 May 1951 (Type of *Microcoleus tenerrimus* var. *longus*). *443 c*, 3 Aug. 1951. Hatake-jima, Tanabe Bay, *466 c*, 2 Aug. 1951.

Shima Peninsula : Wagu, *716 c*, 9 Jun. 1952. O-shima off Wagu, *823 d*, 5 Oct. 1952.

Izu Peninsula : Ebisu-jima near Shimoda, *841 a*, 8 Oct. 1952.

Mi-ura Peninsula : Sendagasaki, Kurihama Bay, *998 b*, 28 Mar. 1953. Aburatsubo, *1005 b*, *1006 b*, *1014 b*, *1025 a*, *1037 b*, *1038 b*, 30 Mar. 1953.

Boso Peninsula : Kominato, *1033 a*, *1068 b*, *1072 b*, *1079 a*, *1080 d*, 3 Apr. 1953. Mera, *1062 c*, 2 Apr. 1953.

Amino : Amino Bay, Kyoto Pref., *782 a*, 24 Sept. 1953. *1131*, 13 Jun. 1953.

Wakasa Bay : Kato, Obama Bay, *55 c*, 8 Sept. 1949.

Hokkaido : Oshoro, *1262 c*, 17 Jul. 1953.

I (Umezaki 1952 a) described a new variety of *Microcoleus tenerrimus*, var. *longus*, for the reason that the cell is much longer and the sheath includes few trichomes. After more careful examination, I have considered that the alga is a young stage of *M. tenerrimus*.

In this species the trichomes are variable in number within the sheath ; even when well matured, the sheaths sometimes enclose only a few trichomes, or some-

times many of them.

This species has been found in all the regions of the Japanese coast, from the Amami Islands to Hokkaido, except in Aomori Prefecture and Matsushima Bay. The alga has been found always associated with other filamentous species, never forming a pure stratum.

Geographical distribution: Cosmopolitan (on rocks and other algae in marine water).

5. **Microcoleus chthonoplastes** Thuret, Ann. Sci. Nat. VI. Bot. 1: 378, 1875; Gomont, Ann. Sci. Nat. VII. Bot. 15: 353, pl. 14, figs. 5–8, 1892; Umezaki, Journ. Jap. Bot. 27: 221, fig. 23, 1952; 1. c. 30: 212, 1955; Publ. Seto Mar. Biol. Lab. 2: 247, 1952; 1. c. 5: 424, 1956.

Plants dark blue-green, widely expanded, or intermixed with other algae; filaments elongate, irregularly curved, 30–90μ in diameter, rarely branched; sheaths hyaline, sometimes diffluent, cylindrical, rough on the surface, apices attenuate, sometimes completely closed or open; trichomes blue-green, 2.5–6μ in diameter, short, nearly straight, numerous within a sheath, usually densely aggregated in bundles, and rarely entwined, apices attenuate; cells 3.5–10μ in length, 1–2 times as long as the diameter; protoplasm granular; apical cell attenuate, neither capitate nor calyptrate. Pl. 5, fig. 2.

Japanese name: Ko-nawamo (Umezaki 1955 a).

Habitat: Growing on rocks in the upper littoral belt or in the supralittoral belt, sometimes associated with other Microcoleus, Hydrocoleum, Lyngbya, and Calothrix.

Amami Islands: Ushuku, Kasari-mura, O-shima, *1855 b*, 13 Apr. 1955. Akakina, Kasari-mura, O-shima, *1866 a*, *1870 c*, 13 Apr. 1955. Koniya, O-shima, *1753 b*, *1755*, *1803 b*, *1806 b*, *1807 b*, *1815 a*, 9–11 Apr. 1955. Naze, O-shima, *1700 a*, 6 Apr. 1955. *1844*, 12 Apr. 1955. *2169*, *2177*, *2181*, 24 Jun. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2029 d*, *2032 a*, *2041*, *2050 b*, 25 May 1956.

Shikoku: Katsurahama, Kochi, *1404 e*, 17 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1593 c*, *1594 b*, 29 Sept. 1954. Hon-jima, Shiaku Islands, *1547 b*, *1548 a*, *1550 b*, 24 Jun. 1950. *1609 b*, 29 Sept. 1954. *1613*, 30 Sept. 1954. *1658*, 8 Feb. 1955. *1915*, *1918 c*, *1933 a*, 5 Aug. 1955. Tadano-umi, Hiroshima Pref., *302 b*, 8 Nov. 1950.

Kii Peninsula: Seto, Shirahama, *532 c*, 1 Nov. 1951. Hatake-jima, Tanabe Bay, *470 c*, 2 Aug. 1951. Wakano-ura, Wakayama, *639 a*, 28 Mar. 1952.

Shima Peninsula: O-shima off Wagu, *809 b*, 5 Oct. 1952. Akogi-ura, Tsu, *679 c*, 7 Jun. 1952.

Izu Peninsula: Ebisu-jima near Shimoda, *841 b*, *851*, 8 Oct. 1952. Shimoda, *856*, *863*, 9 Oct. 1952.

Boso Peninsula: Kominato, *1073 b*, *1079 b*, 3 Apr. 1953.

This cosmopolitan and truly marine and brackish-water species is commonly distributed on the Japanese coast. Especially in the warmer regions the alga grows

very luxuriantly and plentifully; whereas in the northern colder seas bordering Hokkaido, Aomori Prefecture, Matsushima Bay, and on the Japan Sea coast of Honshu, it has not been found. The alga grows mostly associated with other filamentous Cyanophycean species or sometimes in pure fashion, forming the *Microcoleus chthonoplastes* girdle widely expanded on rocks in the supralittoral belt or in the upper littoral belt. Compared with *Microcoleus tenerrimus* the sheath of *M. chthonoplastes* is firmer, although rarely diffluent.

The species was recorded for the thermal flora of Japan by Emoto & Hirose (1952).

Geographical distribution: Cosmopolitan (on rocks and algae in marine and brackish waters).

Tribe II. **Lyngbyeae**

Gomont, Journ. de Bot. 4: 353, 1890; Ann. Sci. Nat. VII. Bot. 16: 91, 1892.

Trichomes vaginate or evaginate, single within a sheath.

Subtribe 1. **Lyngbyinae**

Gomont, Journ. de Bot. 4: 353, 1890; Ann. Sci. Nat. VII. Bot. 16: 96, 1892.

Filaments simple or branched; sheaths firm, usually hyaline, rarely becoming brown; trichomes cylindrical, apices constantly straight.

Genus 6. **Plectonema**

Thuret, Ann. Sci. Nat. VI. Bot. 1: 375, 379, 1875; Gomont, Ann. Sci. Nat. VII. Bot. 16: 96, 1892.—Type species: *P. mirabile* Thur.

Plants lithophytic on rocks, epiphytic on or endophytic in other algae, or perforating mollusk shells, forming expanded strata; filaments vaginate, free, falsely branched; false-branches solitary or geminate; sheaths firm, hyaline, rarely yellowish-brown; trichomes frequently constricted at the cross walls, apices straight, very rarely attenuate; apical cell without a calyptra.

Key to species of Plectonema:

1. Cells longer than the diameter 2
1. Cells shorter than the diameter. 3
2. Branches solitary; cross walls not constricted ..... 1. *P. terebrans*
2. Branches solitary or geminate; cross walls constricted. ..... 2. *P. Nostocorum*
3. Sheaths not attenuate towards apex; cross walls distinctly constricted ..... 3. *P. norvegicum*
3. Sheaths attenuate towards apex; cross walls slighty constricted or not at all ..... 4. *P. calothrichoides*

1. **Plectonema terebrans** Bornet & Flahault, Bull. Soc. Bot. de France 36: 163, pl. 10, figs. 5, 6, 1889; Gomont, Ann. Sci. Nat. VII. Bot. 16: 103, 1892; Umezaki, Journ. Jap. Bot. 29: 217, fig. 39 A, 1954; Publ. Seto Mar. Biol. Lab. 5: 421, 1956.

Plants penetrating mollusk shells, intricate; filaments slender, elongate, falsely branched; branches always single; sheaths very thin, hyaline, cylindrical; trichomes pale blue-green, 0.9–1.5μ in diameter, apices not attenuate; cross walls not constricted, granulate or not, sometimes pellucid; cells 2–6.5μ in length; apical cell round; protoplasm homogeneous. Pl. 5, fig. 3.

Habitat: Growing in dead mollusk shells.

Amami Islands: Asani near Naze, O-shima, *1712 b*, 6 Apr. 1955. Ushuku, Kasari-mura, O-shima, *1876 b*, 13 Apr. 1955. Kasari, O-shima, *2258*, *2276*, 11 Jul. 1958. Seisui near Koniya, O-shima, *2259*, 29 Jun. 1958. Sakihara, Kasari-mura, O-shima, *2468*, 11 Jul. 1958. Tean near Koniya, O-shima, *2245*, 28 Jul. 1959.

Kyushu: Tomioka, Amakusa, *2095 a*, 23 May 1956.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1496 b*, *1498 c*, 22 Jun. 1954. *1657 c*, 5 Aug. 1955. Ozuchi-jima off Tamano, Okayama Pref., *1914 a*, 5 Aug. 1955. Hon-jima, Shiaku Islands, *1603 b*, 29 Sept. 1954. *1673*, 9 Feb. 1955.

Awajishima: Yura, *1398 a*, 13 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *386 c*, *410 b*, 23 May 1951.

Shima Peninsula: O-shima off Wagu, *824 f*, 5 Oct. 1952. *749 d*, 11 Jun. 1952.

Boso Peninsula: Kominato, *1085 b*, 3 Apr. 1953.

Matsushima Bay: Yogasaki, *1150*, M. Kurogi, 10 May 1953.

Wakasa Bay: Koiso, Maizuru Bay, *1360*, 5 Nov. 1953. *1369 b*, 26 Nov. 1953. Jyajima, Maizuru Bay, *2112 b*, 2 Jul. 1956. Sanbon-matsuhana, Maizuru Bay, *1964 b*, 7 Nov. 1955. Suizu, Tsuruga Bay, *208*, 5 Aug. 1950.

Hokkaido: Akkeshi, *1212 b*, 26 Jul. 1953.

Plectonema terebrans, which grows in both marine and fresh waters in mollusk shells, was described by Bornet & Flahault in 1889, when many Chlorophycean and Cyanophycean species boring mollusk shells were discovered by them. On the Japanese coast, this is commonly distributed. From fresh water shells, however, no one has yet discovered it in Japan.

The Japanese plants were mostly associated with other perforating species, *Gomontia polyrhiza*, *Entophysalis deusta*, and *Mastigocoleus testarum*, in mollusk shells. The branching is always single, not geminate, generally sparse. The sheath is very thin, closely fitted. The granules, which generally are present along the cross walls, sometimes have not been found.

Geographical distribution: Subcosmopolitan (in marine and freshwater mollusk shells).

2. **Plectonema Nostocorum** Bornet in Bornet & Thuret, Notes Algol. 2: 137, 1880; Gomont, Journ. de Bot. 4: 353, 1890; Ann. Sci. Nat. VII. Bot. 16: 102, pl. 1, fig. 11, 1892; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 422, fig. 7 A, 1956.

Plants intricate; filaments elongate, slender, straight, flexuous, or subflexuous, sparsely branched; branches mostly single, or geminate; sheaths hyaline, thin, cylindrical; trichomes pale blue-green, 1–1.5μ in diameter; cross walls constricted, not granulate, slightly pellucid; cells 2–2.5μ in length, longer than the diameter;

protoplasm homogeneous; apical cell round. Pl. 5, fig. 4.

Habitat: Growing on Ulva and Calothrix, or in the strata of Lyngbya.

Amami Islands: Yamma, Sumiyo-mura, O-shima, *1736 d*, 8 Apr. 1955. Tean near Koniya, O-shima, *2234*, 28 Jun. 1958. Ikeji, Kikai-jima, *2372*, 6 Jul. 1958.

Plectonema Nostocorum has been found only from the Amami Islands in Japan. From hot springs of Japan, Emoto & Hirose (1942) and Yoneda (1952 a) have reported it.

Geographical distribution: Cosmopolitan (among gelatinous algae, or in the matrix of gelatinous algae in fresh or marine water, occasionally subaerophytic).

3. **Plectonema norvegicum** Gomont, Bull. Soc. Bot. de France 46: 34, 1899; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 421, fig. 6 A, 1956.

Plants brown or brownish-green, densely intricate; filaments irregularly curved, mostly up to 100μ in length, 2.5–3.5μ in diameter, more or less frequently branched; branches mostly geminate, or single; sheaths hyaline, not attenuate towards the apex; trichomes pale blue-green, 1.5–2μ in diameter; cross walls distinctly constricted; cells 1–½ times as long as the diameter; protoplasm homogeneous; apical cell round. Pl. 5, fig. 5.

Habitat: Growing on the filaments of Lyngbya and Calothrix, rarely on rocks in the upper littoral belt.

Amami Islands: Asani near Naze, O-shima, *1698 b*, 6 Apr. 1955. Gusuku, Sumiyo-mura, O-shima, *1729 b*, 7 Apr. 1955. Yamma, Sumiyo-mura, *1741 b*, 8 Apr. 1955.

Kyushu: Ao-shima, Miyazaki Pref., *2073 b*, 27 May 1956. Tomioka, Amakusa, *2013 b*, *2016 c*, 23 May 1956.

Shikoku: Usa, Kochi Pref., *1412 d*, *1418 c*, 15 Jun. 1954.

Kii Peninsula: Hatake-jima, Tanabe Bay, *446 c*, *451 c*, *467 d*, 2 Aug. 1951. *466 d*, 2 Aug. 1951 (as *Phormidium constrictum* by Umezaki, 1952 a). Yuzaki, Shirahama, *496 b*, 31 Oct. 1951.

Shima Peninsula: Wagu, *609 b*, 12 Mar. 1952. *703 b*, 9 Jun. 1952. Koshika, *602 b*, 11 Mar. 1952.

Enoshima: Enoshima, Kanagawa Pref., *1053 c*, *1054 b*, 31 Mar. 1953.

Mi-ura Peninsula: Aburatsubo, *1011 c*, *1013 b*, 29 Mar. 1953.

Boso Peninsula: Kominato, *1075 d*, *1088 b*, 3 Apr. 1953.

Amino: Amino Bay, Kyoto Pref., *962 b*, 24 Feb. 1952.

Wakasa Bay: Takahama, Fukui Pref., *129 b*, 15 Jan. 1950. Jyogu, Tsuruga Bay, *158 b*, 28 May 1950.

Hokkaido: Muroran, *1213 c*, 14 Jul. 1953. Oshoro, *1250 c*, 17 Jul. 1953.

Plectonema norvegicum was described along with several new species of Plectonema and other Oscillatoriaceae by Gomont in 1899, on the basis of the collections of Foslie, Golenkin, Collins, Bory, Batters, and others.

According to Gomont's diagnosis the plant is crustaceous and light brown or brownish-green in colour. But the majority of the present specimens have been found epiphytic on other algae, mostly on filamentous Cyanophycean species such as *Calothrix crustacea*, *C. scopulorum*, *C. pilosa*, and *Lyngbya semiplena*, and rarely

growing on rocks. Excepting for the habitat, other characteristics are typical.

Geographical distribution: On rocks in marine water. Atlantic coast of North America (Florida); Australia (South Australia).

4. **Plectonema calothrichoides** Gomont, Bull. Soc. Bot. de Fr. 46: 30, pl. 1, figs. 6–10, 1899; Umezaki, Acta Phytotax. Geobot. 16: 88, fig. 4 B, 1556; Publ. Seto Mar. Biol. Lab. 5: 422, 1956.

Plants forming a brownish-green, expanded stratum; filaments somewhat elongate, nearly straight or slightly flexible, up to 500μ in length, 3–5–(7.5)μ in diameter, branched, apices attenuate; branches geminate or single; sheaths thick, hyaline, but brown in the middle portion, gradually becoming thin and faded at the apex; trichomes pale blue-green, 2–2.5–(4)μ in diameter; cross walls constricted or sometimes not; cells nearly quadrate or 1/2–1/3 as short as the diameter; protoplasm homogeneous or finely granular; apical cell round. Pl. 6, fig. 1.

Habitat: Growing on rocks in the upper littoral belt, rarely epiphytic on other algae (Gelidium and *Nemalion pulvinatum*).

Amami Islands: Yamma, Sumiyo-mura, O-shima, *1744*, 8 Apr. 1955. Gusuku, Sumiyo-mura, O-shima, *1728*, 7 Apr. 1955. Ikeji, Kikai-jma, *2357*, 6 Jul. 1958.

Kyushu: Aoshima, Miyazaki Pref., *2072 a*, 27 May 1956.

Shikoku: Katsurahama, Kochi, *1402 c*, *1404 a*, 17 Jun. 1954. Tsuro near Cape Ashizuri, *1475 d*, 19 Jun. 1954.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1501*, 22 Jun. 1954. Ozuchi-jima off Tamano, Okayama Pref., *1681 b*, 10 Feb. 1955. Hon-jima, Shiaku Islands, *1542 b*, 23 Jun. 1954. *1939 b*, 5 Aug. 1955.

Kii Peninsula: Seto, Shirahama, *520*, 1 Nov. 1951.

Shima Peninsula: Wagu, *611 b*, 12 Mar. 1952. Goza, *610 c*, 12 Mar. 1952. *750 b*, 11 Jun. 1952. O-shima off Wagu, *729 b*, 10 Jun. 1952.

Enoshima: Enoshima, Kanagawa Pref., *1049*, *1051 c*, *1055*, 31 Mar. 1953.

Mi-ura Peninsula: Aburatsubo, *1011 b*, 29 Mar. 1953.

Boso Peninsula: Kominato, *1076*, *1088 c*, 3 Apr. 1953. Futomi, *1095 b*, *1100 b*, 4 Apr. 1955.

Matsushima Bay: Yogasaki, *1144*, *1145*, *1146*, 7 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *781*, 24 Sept. 1952. *954 b*, 29 Jan. 1953.

Wakasa Bay: Kanzaki, Kunda Bay, *82*, *84 b*, *85 b*, 30 Sept. 1949. Koiso, Maizuru Bay, *66 b*, 25 Sept. 1949. Kanmuri-jima off Maizuru Bay, *37 b*, 10 Aug. 1949 (as *Schizothrix septentrionalis* by Umezaki, 1953, 53 a). Nagahama, Maizuru Bay, *580*, 1 Mar. 1952. *916 b*, 24 Nov. 1952 (as *Lyngbya lithophila* by Umezaki, 1953). *1364 b*, 21 Nov. 1953. *1382 b*, 3 Feb. 1954. Obama, Obama Bay, *152 a*, 6 May 1950. *583 b*, 2 Mar. 1952. Kanagasaki, Tsuruga Bay, *220 b*, 29 Sept. 1950.

Aomori Pref.: Asamushi near Aomori, *1208*, 9 Jul. 1953.

Hokkaido: Muroran, *1213 b*, *1214*, 14 Jul. 1953. Oshoro, *1262 b*, 17 Jul. 1953. Rebun-to, *1304*, 30 Jul. 1953. Rishiri-to, *1345*, 3 Aug. 1953.

Plectonema calothrichoides is one of the most commonly distributed species in the genus Plectonema in Japan. In the Japanese specimens the filaments are very elongate, sometimes measuring 500μ in length; and the sheaths are mostly coloured

light brown, lamellate and attenuated in the apical portions. The branching is generally sparse, mostly single.

Geographical distribution: On rocks in marine water and soil near shore. Atlantic coast of Europe (Sweden, France); Mediterranean (France); Atlantic coast of North America (Massachusetts, Florida).

Genus 7. **Lyngbya**

C. Agardh, Syst. Algar., p. 25, 1824; Gomont, Ann. Sci. Nat. VII. Bot. 16: 118, 1892. —Type species: *L. confervoides* C. Ag.

Plants free, or dense, floccose, caespitose, pannose, attached or free-floating; filaments vaginate, simple; sheaths firm, thin, hyaline or coloured, homogeneous, or later sometimes becoming thick, lamellate; trichomes single within a sheath, unbranched or rarely branched; cross walls sometimes constricted; apices of trichomes straight, obtuse or sometimes slightly attenuate; apical cell sometimes with a thickened calyptra; reproduction by hormogones.

Key to species of Lyngbya:

Subgenus I. **Leibleinia.** Plants epiphytic; filaments attached at the middle, both ends erect; sheaths thin, hyaline; apex of trichome not attenuate.

1. Trichomes 1.5-2(rarely 2.5)μ in diameter ..... 1. *L. Nordgaardii*
1. Trichomes 6-31(rarely 51)μ in diameter 2
2. Trichomes 6-12μ in diameter. 3
2. Trichomes 20-31(rarely 51)μ in diameter ..... 2. *L. sordida*
3. Trichomes violet-green, 6-8.5μ in diameter. ..... 3. *L. gracilis*
3. Trichomes greenish-violet, 7-12 (mostly 9)μ in diameter ..... 4. *L. baculum*

Subgenus II. **Eulyngbya.** Plants floccose or caespitose; filaments attached at the base or entangled; sheaths often becoming thick and lamellate with age; apex of trichome sometimes attenuate.

1. Plants epiphytic on or endophytic in other algae. 2
1. Plants lithophytic on rocks 5
2. Trichomes 0.7-1.5μ in diameter 3
2. Trichomes 1.5-3.3μ in diameter 4
3. Plants spirally twisted about other filamentous algae; trichomes 1-1.5μ in diameter ..... 5 *L. epiphytica*
3. Plants usually endophytic; trichomes 0.7-0.9μ in diameter. ..... 6. *L. Rivulariarum*
4. Filaments attached throughout the length to other algae. ..... 7. *L. pellucida*
4. Filaments attached at the base to other algae ..... 8. *L. infixa*
5. Apical cell with calyptra 6
5. Apical cell without calyptra. 8
6. Filaments occasionally branched; trichomes 11-22μ in diameter ..... 9. *L. aestuarii*
6. Filaments unbranched; trichomes 2.5-15μ in diameter. 7
7. Trichomes 2.5-5-(6)μ in diameter ..... 10. *L. lutea*
7. Trichomes 7-15μ in diameter. ..... 11. *L. semiplena*

8. Trichomes 9-25μ in diameter; cells 1/3-1/8 as short as the diameter. ..... 12. *L. confervoides*
8. Trichomes 15-35-(43.5)μ in diameter; cells 1/5-1/15 as short as the diameter,..... ..... 13. *L. majuscula*

Subgenus I. **Leibleinia**

Gomont, Journ. de Bot. 4: 354, 1890; Ann. Sci. Nat. VII. Bot. 16: 122, 1892.

Plants epiphytic, submerged; filaments attached at the middle, erect at both ends; sheaths thin, hyaline, not evidently lamellate; apex of trichome not attenuate.

1. **Lyngbya Nordgaardii** Wille seq. Frémy, Mém. Soc. Nat. Sci. Nat. Math. de Cherbourg 41: 111, pl. 29, fig. 5, 1934; Umezaki, Journ. Jap. Bot. 26: 203, fig. 8, 1951; 1. c. 30: 210, 1955; Publ. Seto Mar. Biol. Lab. 2: 245, 1952; 1. c. 5: 423, 1956; Acta Phytotax. Geobot. 16: 89, 1956.

Lyngbya Willei Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 468, 1918.

Plants solitary or small caespitose; filaments attached at the middle, elongate, straight, or flexuous, 150–300μ in length; sheaths very thin, hyaline; trichomes grayish-green or blue-green, 1.5–2 (rarely 2.5)μ in diameter, apices not attenuate; cross walls constricted, not granulate; cells nearly quadrate or 1/2 as short as the diameter; protoplasm homogeneous; apical cell round, the outer wall not thickened, neither capitate nor calyptrate. Pl. 6, fig. 3.

Habitat: Growing on larger algae (Gelidium, Caulacanthus, Cladophora, and Calothrix).

Amami Islands: Gusuku, Sumiyo-mura, O-shima, *1726 b*, 7 Apr. 1955.
Shikoku: Usa, Kochi Pref., *1418 b*, 15 Jun. 1954.
Kii Peninusla: Seto, Shirahama, *388 b*, *409*, 22 May 1951.
Shima Peninsula: Wagu, *793 b*, 4 Oct. 1952.
Wakasa Bay: Tagarasu near Obama, *115 c*, 23 Dec. 1949.
Hokkaido: Muroran, *1217 b*, 14 Jul. 1953. Akkeshi, *1298 b*, 28 Jul. 1953.

Lyngbya Nordgaardii was renamed on the basis of its original species, *L. epiphytica* Wille (1913), because the latter name has already been occupied by Hieronymus (*L. epiphytica* Hieron., 1898). Gardner (1918), perhaps without looking at Wille's publication (of *L. Nordgaardii* Wille, 1918), gave it a new name, *L. Willei*. Both specimens, the type of *L. Nordgaardii* from Trondheim, Norway and the material of *L. Willei* from Marin County, California, were discovered on Rhizoclonium, *R. hieroglyphicum* and *R. riparium* var. *polyrhizum*. The Japanese plants were found growing on various small algae, sometimes on filamentous Cyanophycean species such as *Calothrix crustacea* and *C. scopulorum*.

Geographical distribution: On marine algae. Atlantic coast of Europe (Norway); North Africa (Egypt, Tunisia); West Indies (Danish West Indies); Pacific coast of North America (Washington, California); Indian Ocean (India).

2. **Lyngbya sordida** (Zanardini) Gomont, Ann. Sci. Nat. VII. Bot. 16: 126, pl.

2, fig. 21, 1892; Umezaki, Journ. Jap. Bot. 25: 227, fig. 6, 1950; l. c. 30: 210, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 71, pl. 5, fig. 1, 1953; Publ. Seto Mar. Biol. Lab. 5: 423, 1956.

Plants fasciculate, dark green or dark yellowish-green, up to 3 cm. in length; filaments straight, subrigid, 24–31 (rarely 59)μ in diameter; sheaths hyaline, thin, not lamellate, firm, up to 2 (rarely 4)μ in thickness; trichomes blue- or yellow-green, 20–29 (rarely 51)μ in diameter; cross walls markedly constricted, not granulate; cells 3–9μ in length, 1/2–1/6–(1/7) as short as the diameter; protoplasm large-granular; apical cell round, without calyptra. Pl. 6, fig. 4.

Habitat: Growing on larger algae (Gelidium, Griffithsia, Centroceras, Sargassum, Codium, and Acetabularia).

Amami Islands: Koniya, O-shima, *1809*, 11 Apr. 1955. Seisui near Koniya, O-shima, *2249*, 29 Jun. 1958. Ushuku, Kasari-mura, O-shima, *1860*, *1861*, 13 Apr. 1955. Kasari, O-shima, *2264*, 11 Jul. 1958. So-machi, Kikai-jima, *2392*, 7 Jul. 1958.

Shima Peninsula: O-shima off Wagu, *828*, 5 Oct. 1952.

Amino: Amino Bay, Kyoto Pref., *786 b*, 24 Sept. 1952.

Wakasa Bay: Nagahama, Maizuru Bay, *59 a*, 12 Sept. 1949. *100*, 24 Aug. 1948. Kato, Obama Bay, *58*, 8 Sept. 1949. Ao-shima, Obama Bay, *94*, 22 Oct. 1949. Takahama, Fukui Pref., *1586 a*, 1 Sept. 1954. Suizu, Tsuruga Bay, *210 a*, 5 Aug. 1950.

Lyngbya sordida is a species of the subgenus Leibleinia with the thickest filaments, which rarely measure 59μ in the Japanese specimens. In fresh materials the cross walls of the trichome are slightly constricted, but when dried or placed in slightly concentrated solution of various kinds they are markedly constricted and the cell becomes very short. Physiologically the protoplasm seems to be very dilute, —perhaps the osmotic pressure is very low as compared with that of other species of Lyngbya.

Geographical distribution: Subcosmopolitan (on various marine algae).

3. **Lyngbya gracilis** (Meneghini) Rabenhorst, Fl. Eur. Algar. 2: 145, 1865; Hauck, Rabenh. Krypt. Fl. 2: 506, 1885; Gomont, Ann. Sci. Nat. VII. Bot. 16: 124, pl. 2, fig. 20, 1892; Umezaki, Publ. Seto Mar. Biol. Lab. 2: 245, 1952; l. c. 5: 423, fig. 6 B, 1956.

Plants floccose, purple-violet; filaments flexible or nearly erect, 7.5–11μ in diameter, up to 0.5 mm. in length; sheaths hyaline, thin, smooth; trichomes violet-green, 6–8.5μ in diameter, apices not attenuate; cross walls constricted, not granulate; cells 2.5–6μ in length, quadrate or 1/2–1/3 as short as the diameter; protoplasm finely granular; apical cell round, the outer wall not thickened. Pl. 6, fig. 5.

Habitat: Growing on larger algae (Caulacanthus and Corallina), or on shaded rocks in the upper littoral belt.

Amami Islands: Asani near Naze, O-shima, *1709 a*, 6 Apr. 1955. Koniya, O-shima, *1813 a*, 11 Apr. 1955.

Kii Peninsula: Seto, Shirahama, *439 a*, 3 Aug. 1951.

The plants from the Japanese coast, where their occurrence is very rare, are very short, up to 0.5 mm. long, although they are described in the original diagnosis to be 5–15 mm. long.

Geographical distribution: Subcosmopolitan (on various marine algae).

4. **Lyngbya baculum** Gomont, Journ. de Bot. 4: 354, 1890; Ann. Sc. Nat. VII. Bot. 16: 123, pl. 2, fig. 17, 1892.

Plants solitary or more or less caespitose; filaments slightly arcuate, rigid, up to 1 cm. in length, 10–15μ in diameter; sheaths hyaline, thick, firm; trichomes greenish-violet, 7–12 (mostly 9)μ in diameter; cross walls slightly constricted or not, not granulate; cells 3–9μ in length, nearly quadrate or up to 1/3 as short as the diameter; protoplasm finely granular; apical cell round, more or less enlarged or not, without calyptra. Pl. 6, fig. 6.

Habitat: Growing on Laurencia and *Calothrix crustacea*.

Shima Peninsula: Wagu, *799*, 4 Oct. 1952.

Wakasa Bay: Tagarasu near Obama, *114 b*, 23 Dec. 1949.

The specimens from Shima Peninsula have the filaments 1 cm. long, 12–13μ broad and the trichomes 7.5–9μ broad; and the specimens from Wakasa Bay have the filaments up to 1 cm. long and 10–15μ broad and the trichomes 7–12μ broad. All the specimens of Japan have the trichomes greenish-violet in colour.

Geographical distribution: On various marine algae. Atlantic coast of Europe (France); Indian Ocean (India).

Subgenus II. **Eulyngbya**

Gomont, Journ. de Bot. 4: 354, 1890; Ann. Sci. Nat. VII. Bot. 16: 127, 1892.

Plants floccose, widely expanded, or caespitose; filaments attached at the base, even floating free; sheaths often becoming thick and lamellate with age, sometimes yellowish-brown; apex of trichome sometimes attenuate.

5. **Lyngbya epiphytica** Hieronymus in Kirchner, Engler & Prantl, Natuerl. Pflanzenfam., I, 1 a, p. 67, 1898; Umezaki, Journ. Jap. Bot. 25: 226, fig. 5, 1950; l. c. 30: 210, 1955; Publ. Seto Mar. Biol. Lab. 2: 245, 1952; Bot. Mag. Tokyo 68: 68, 1955; Acta Phytotax. Geobot. 16: 88, 1956.

Plants solitary or more or less aggregate; filaments attached throughout the length to other filamentous algae and spirally twisted about them, 1.5–2.5μ in diameter; sheaths hyaline, very thin; trichomes pale blue-green, 1–1.5μ in diameter, apices not attenuate; cross walls not constricted, not granulate; cells 1–2–(2.5)μ in length; protoplasm homogeneous; apical cell round, without calyptra. Pl. 6, fig. 2.

Japanese name: Itomakimo (Umezaki 1950).

Habitat: Growing on the filaments of other Lyngbya and Calothrix.

Amami Islands: Ushuku, Kasari-mura, O-shima, *2427*, *2429*, 10 Jul. 1958. Ankyaba, Kake-

roma-to, *2327*, *2331*, 30 Jun. 1958.

Tokara Islands: Takara-jima, *1139 c*, E. Ogata, 27 May 1953.

Kyushu: Tsuyasaki, Fukuoka Pref., *1983 b*, 21 May 1956.

Shikoku: Usa, Kochi Pref., *1417 b*, 15 Jun. 1954.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1627 b*, 30 Sept. 1954.

Kii Peninsula: Seto, Shirahama, *399 c*, 23 May 1951. *517 b*, 1 Nov. 1951. Yuzaki, Shirahama, *495 b*, 31 Oct. 1951. Hatake-jima, Tanabe Bay, *467 b*, 2 Aug. 1951.

Shima Peninsula: O-shima off Wagu, *617 b*, 12 Mar. 1952. *810 c*, 5 Oct. 1952. Koshika, *602 c*, 11 Mar. 1952.

Izu Peninsula: Shimoda, *858 b*, 9 Oct. 1952.

Matsushima Bay: Katsura-shima, *1167 c*, 8 Jul. 1953.

Wakasa Bay: Koiso and Sanbonmatsuhana, Maizuru Bay, *130 b*, 3 Feb. 1953. *1130 c*, 27 May 1953. Tagarasu near Obama, *116 b*, 23 Dec. 1949.

Aomori Pref.: Asamushi near Aomori, *1188 b*, 9 Jul. 1953.

Hokkaido: Muroran, *1241 c*, 15 Jul. 1953. Oshoro, *1258 d*, 17 Jul. 1953.

The Japanese plants of *Lyngbya epiphytica*, which grow usually on various algae in freshwater, rarely in marine water, have been found on the plants of other filamentous Cyanophycean species, mostly of Lyngbya and Calothrix, spiraling loosely or closely about them. The cross walls of the trichome are generally obscure, but rarely distinct.

This is also common in fresh and thermal waters of Japan (Emoto & Hirose 1940, 42, 42 a, 49; Emoto & Yoneda 1940, 41, 41 a, 42; and Yoneda 1940, 41 b, 52 a, 53).

Geographical distribution: Subcosmopolitan (on various algae in freshwater and often in marine water).

6. **Lyngbya Rivulariarum** Gomont, Ann. Sci. Nat. VII. Bot. 16: 148, 1892; Umezaki, Journ. Jap. Bot. 31: 35, fig. 42 B, 1956; Publ. Seto Mar. Biol. Lab. 5: 423, 1956.

Plants growing on or in gelatinous algae, solitary or more or less gregarious; filaments very slender, irregularly curved, twisted, or nearly straight; sheaths hyaline, very thin; trichomes pale blue-green, 0.7–0.9μ in diameter, apices not attenuate; cross walls not constricted, not granulate, often pellucid; cells 2–3.3μ in length; protoplasm homogeneous; apical cell round, witout calyptra. Pl. 7, fig. 1.

Habitat: Growing on or in the sheaths of Hydrocoleum (*H. cantharidosmum*, *H. glutinosum*, and *H. lyngbyaceum*) and Lyngbya (*L. aestuarii*), or in the plants of *Rivularia polyotis* and *Brachytrichia Quoyi*.

Amami Islands: Asani near Naze, O-shima, *1706 b*, 6 Apr. 1955 (as *Phormidium epiphyticum* by Umezaki, 1956 c). Yamma, Sumiyo-mura, O-shima, *1745 c*, *1750 c*, 8 Apr. 1955 (as *Phormidium epiphyticum* by Umezaki, 1956 c). Ushuku, Kasari-mura, O-shima, *1855 d*, 13 Apr. 1955 (as *Phormidium epiphyticum* by Umezaki, 1956 c). Sakihara, Kasari-mura, O-shima, *2463*, 11 Jul. 1958. Koniya, O-shima, *1796 b*, 11 Apr. 1955. Tean near Koniya, O-shima, *2199*, 28 Jun. 1958. Ankyaba, Kakeroma-to, *2334*, 30 Jun. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2048 b*, 25 May 1956. Tomioka, Amakusa, *2007 b*, 23 May 1956. Shingu, Fukuoka Pref., *1969 c*, *1971 d*, 20 May 1956.

Shimonoseki: Yoshimi, *266 c*, 5 Nov. 1950.

Shikoku: Usa, Kochi Pref., *1429 b*, *1430 c*, *1431 b*, 15 Jun. 1954. O-urasaki near Cape Ashizuri, *1473 b*, 19 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1522 e*, 23 Jun. 1954.

Kii Peninsula: Senjyojiki, Shirahama, *513 b*, 31 Oct. 1951 (as *Phormidium epiphyticum* by Umezaki, 1952 a, 53).

Shima Peninsula: Wagu, *718 e*, 9 Jun. 1952 (as *Phormidium epiphyticum* by Umezaki, 1953, 55 a).

Wakasa Bay: Kato, Obama Bay, *430 b*, 21 Jun. 1951.

Hokkaido: Oshoro, *1258 e*, 17 Jul. 1953 (as *Phormidium epiphyticum* by Umezaki, 1956 a).

The original description of *Phormidium epiphyticum* Gardn. (1932) the type of which was found growing on *Lyngbya aestuarii*, in company with *Spirulina socialis* Gardn., in San Juan, Puerto Rico, is similar in many respects to that of *Lyngbya Rivulariarum*, which usually grows endophytic in gelatinous algae. The Japanese plants of *L. Rivulariarum*, however, have been found growing not only endophytic in gelatinous algae, mostly in the sheaths of Hydrocoleum, but epiphytic on gelatinous algae. The specimens which have been referred to *Phormidium epiphyticum* by me (1952 a, 53, 55 a, 56 a, c) are placed in *Lyngbya Rivulariarum* where they seem to be most satisfactorily disposed of.

Geographical distribution: In gelatinous subaerial algae and in similar aquatic algae in fresh and marine waters. Atlantic coast of Europe (France, British Isles); Mediterranean (Adriatic Sea); Pacific Ocean (Hawaiian Islands); Indian Ocean (Madagascar).

7. **Lyngbya pellucida** Umezaki, Bot. Mag. Tokyo 68: 68, fig. 1, 1955.

Plants solitary or more or less gregarious; filaments attached throughout the length to other algae, nearly erect or curved; sheaths hyaline, thin; trichomes pale aeruginous, apices not attenuate; cross walls not constricted, not granulate, usually pellucid; cells 1.5–2.4–(3)μ in diameter, 1.3–4μ in length; protoplasm homogeneous; apical cell round, neither capitate nor calyptrate. Pl. 6, fig. 7.

Habitat: Growing on or among the filaments of Lyngbya (*L. majuscula*, *L. semiplena*, and *L. aestuarii*).

Amami Islands: Sakihara, Kasari-mura, O-shima, *2461*, 11 Jul. 1958. Ikeji, Kikai-jima, *2374*, 6 Jul. 1958. So-machi, Kikai-jima, *2390*, 7 Jul. 1958.

Tokara Islands: Takara-jima, on *Lyngbya aestuarii*, *1139 e*, E. Ogata, 27 May 1953 (Type).

The plants of this species grow generally in solitary fashion, or form rarely more or less gregarious strata on or among the host algae like those of *Lyngbya epiphytica*. The filaments with short length are nearly erect. The cross walls are usually pellucid and wide.

This species is closely related to *Lyngbya epiphytica* Hiron. and *L. Rivulariarum* Gom., but differs from the latter two species in the following points: a, the cross

walls of the trichome are more apparently pellucid; b, the trichomes are more thicker; and c, the filaments are generally more shorter and nearly erect.

This minute alga has been found only from the warmer areas of Japan.

8. **Lyngbya infixa** Frémy, Compt. Rend. Acad. Sci. Paris 195: 1414, 1932; Mém. Soc. Nat. Sci. Nat. Math. de Cherbourg 41: 110, pl. 30, fig. 1, 1934; Umezaki, Journ. Jap. Bot. 28: 364, fig. 35 A, 1953; Bot. Mag. Tokyo 68: 68, 1955; Acta Phytotax. Geobot. 16: 88, 1956; Publ. Seto Mar. Biol. Lab. 5: 423, 1956.

Plants epiphytic, solitary or more or less loosely associated; filaments attached at the bases, nearly erect or subflexuous, considerably elongate, up to 400μ, mostly 200–300μ in length; sheaths hyaline, very thin, firm; trichomes pale blue-green, 1.5–2.5–(3.5)μ in diameter, apices not attenuate; cross walls not constricted, not granulate, slightly pellucid; cells 0.8–2.4–(3)μ in length, quadrate or 1/2–1/3 as short as the diameter; protoplasm finely granular; apical cell round, neither capitate nor calyptrate. Pl. 7, fig. 2.

Habitat: Growing on various larger algae (Gelidium, Pterocladia, Delisea, Griffithsia, Bostrychia, Ptilota, Antithamnion, Euzoniella, Sphacelaria, Cladophora, Chaetomorpha, and Codium).

Amami Islands: Asani near Naze, O-shima, *1701 c*, 6 Apr. 1955.

Tokara Islands: Nakano-shima, *1140 f*, E. Ogata, 5 Jun. 1953.

Kyushu: Ushinohama, Kagoshima Pref., *2053 c*, 25 May 1956.

Shikoku: Tsuro near Cape Ashizuri, *1487 b*, *1488*, 20 Jun. 1954.

Izu Peninsula: Hamazaki-mura near Shimoda, *896*, 8 Oct. 1952.

Enoshima: Enoshima, Kanagawa Pref., *992*, 31 Mar. 1953.

Boso Peninsula: Futomi, *1030*, 4 Apr. 1953.

Matsushima Bay: Katsura-shima, *1179*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *978*, 15 Mar. 1953.

Wakasa Bay: Koiso, Maizuru Bay, *101 b*, 11 Nov. 1949 (as *Lyngbya Kuetzingii* by Umezaki, 1952). Sanbonmatsuhana, Maizuru Bay, *1379 a*, 12 Jan. 1954. Kato, Obama Bay, *952*, 23 Jan. 1953. *969 c*, 28 Feb. 1953. *1116*, 29 Apr. 1953.

Aomori Pref.: Asamushi near Aomori, *1202*, *1203*, *1205*, *1206*, 9 Jul. 1953.

Hokkaido: Muroran, *1219*, *1224*, 14 Jul. 1953. Oshoro, *1252 a*, 17 Jul. 1953. Rebun-to, *1313*, 31 Jul. 1953.

The type locality of *Lyngbya infixa* is Banyuls on the Mediterranean coast of France, where its type specimen was found on *Codium tomentosum*, which was collected by J. Feldmann. The Japanese plants have been found growing on various algae and their characteristics are on the whole typical. A specimen which was referred to *Lyngbya Kuetzingii* by me (1952) is the young and dwarf plants of *Lyngbya infixa*.

Geographical distribution: On various marine algae. Atlantic coast of Europe (Sweden); Mediterranean (France); North Africa (Egypt); Atlantic coast of North America (Florida); West Indies (Curacao Island); Indian Ocean (India, Ceylon).

9. **Lyngbya aestuarii** (Mertens) Liebman seq. Gomont, Ann. Sci. Nat. VII. Bot. 16: 127, pl. 3, figs. 1, 2, 1892; Umezaki, Journ. Jap. Bot. 28: 237, fig. 31 C, 1953; l. c. 30: 211, 1955; Bot. Mag. Tokyo 68: 69, 1955; Acta Phytotax. Geobot. 16: 89, 1956; Publ. Seto Mar. Biol. Lab. 5: 424, 1956.

Plants forming a widely expanded, thick, olive-green or dark blue-green stratum; filaments elongate, densely intricate, very flexuous, 16–31μ in diameter, occasionally branched; sheaths at first hyaline, thin, smooth, with age becoming thick, rough on the surface and lamellate, sometimes changing to yellowish or brownish colour; trichomes blue-green or olive-green, 11–22μ in diameter, apices slightly attenuate or not; cross walls not constricted, granulate or not; cells 2–5.5μ in length, 1/3–1/6–(1/7) as short as the diameter; protoplasm finely granular; apical cell round, subacute or conical, with slightly thickened outer wall. Pl. 8, fig. 1.

Forma **aeruginosa** Gomont, l. c. 1892.

Plants pale blue-green; sheaths hyaline, moderately thin.

Forma **spectabilis** (Thuret) Gomont, l. c. 1892.

Sheaths very thick, up to 10μ in thickness, hyaline in the exterior, changing to yellowish-golden-yellow in the interior.

Habitat: Growing on rocks, rarely on other algal masses, in the lower or upper littoral belt, or in the supralittoral belt.

Amami Islands: Koniya, O-shima, *1754 a*, *1756 a*, *1763 a*, *1764 a*, *1784 a*, *1806 a*, *1816 b*, *1822 a*, *1883*, 10–11 Apr. 1955. Tean near Koniya, O-shima, *2189*, *2194*, *2220*, *2240*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2304*, 29 Jun. 1958. Urasokari near Koniya, O-shima, *2538*, 1 Jul. 1948. Ushuku, Kasari-mura, O-shima, *2426*, 10 Jul. 1958. Ankyaba, Kakeroma-to, *2328*, *2337*, *2494*, 30 Jun. 1958. Ikeji, Kikai-jima, *2352*, *2355*, *2356*, *2364*, *2369*, *2370*, *2371*, *2375*, 6 Jul. 1958. Wan, Kikai-jima, *2406*, *2413*, 8 Jul. 1958.

Tokara Islands: Takara-jima, *1139 l*, E. Ogata, 27 May 1953.

Kyushu: Ushinohama, Kagoshima Pref., *2049 a*, *2051 a*, 25 May 1956. Tomioka, Amakusa, *2000 g*, 22 May 1956.

Shikoku: Usa, Kochi Pref., *1421 a*, *1452*, 15–16 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1905 a*, 5 Aug. 1955. Honjima, Shiaku Islands, *1548 b*, *1555 d*, 24 Jun. 1954. *1601*, *1602*, 29 Sept. 1954. *1945 c*, *1946 c*, 6 Aug. 1955.

Kii Peninsula: Seto, Shirahama, *388 c*, 22 May 1951. Senjyojiki, Shirahama, *511 c*, 31 Oct. 1951. Mio, Hidaka, *633 a*, T. Yamamoto, 29 Aug. 1951.

Shima Peninsula: O-shima off Wagu, *724 d*, *728 b*, 10 Jun. 1952. *808 c*, 5 Oct. 1952. Wagu, *702 a*, *704 a*, *716 b*, 9 Jun. 1952. *801 b*, *827 b*, 5 Oct. 1952. Goza, *593 c* *596 b*, 11 Mar. 1952.

Wakasa Bay: Kanmuri-jima off Maizuru Bay, *34*, 23 Jul. 1949. Kato, Obama Bay, *9 a*, *12*, *17 b*, *18*, 22 Jun. 1949. Tsunekami, Cape Tsunekami, *483*, 8 Aug. 1951.

Hokkaido: Muroran, *325 a*, 22 Jul. 1947. Oshoro, *1253 f*, *1254 b*, 17 Jul. 1953. Hariusu near Otaru, *324 a*, 31 Aug. 1947. Lake Saroma, Kitami, *339 a*, K. Iwamoto, Aug. 1947.

Among the two forms here referred f. *aeruginosa* is most common on the Japanese coast; while f. *spectabilis*, the sheath of which is up to 10μ thick and

yellowish-golden-yellow in colour, is rare and is more frequently branched than is f. *aeruginosa*. This species has been found mostly on rocks, rarely on other small or large algal masses, usually associated with other filamentous Cyanophycean species such as Hydrocoleum, Oscillatoria and Calothrix.

From hot springs of Japan this species was also reported by Emoto & Hirose (1952), Emoto & Yoneda (1942 a), Molisch (1926), and Yoneda (1942, 42 a, 52 a).

Geographical distribution: Cosmopolitan (attached or floating mostly in marine and brackish waters, rarely in fresh or thermal waters).

10. **Lyngbya lutea** (Agardh) Gomont, Journ. de Bot. 4: 354, 1890; Ann. Sci. Nat. VII. Bot. 16: 141, pl. 3, figs. 12, 13, 1892; Yoneda, Acta Phytotax. Geobot. 7: 174, fig. 120, 1938; Umezaki, Journ. Jap. Bot. 26: 204, fig. 11, 1951; 1. c. 30: 211, 1955; Publ. Seto Mar. Biol. Lab. 2: 246, 1952; 1. c. 5: 424, 1956; Mem. Coll. Agr., Kyoto Univ. 66: 72, pl. 5, fig. 3, 1953; Acta Phytotax. Geobot. 16: 89, 1956.

Plants forming a subgelatinous, leathery, yellowish-green or olive-green stratum; filaments flexible, twisted and densely entangled at the base, 4.5–8–(11)μ in diameter, up to 3 mm. or 5 mm. in length; sheaths hyaline, smooth, at first thin, later becoming lamellate; trichomes olive-green, 2.5–5–(6)μ in diameter, apices not attenuate; cross walls not constricted, usually obscure, rarely granulate, or not; cells 1.5–5.5μ in length, quadrate or 1/2–1/3 as short as the diameter; protoplasm finely granular; apical cell with calyptra of various shape. Pl. 7, fig. 3.

Habitat: Growing on rocks and concrete in the upper littoral or supralittoral belt, or epiphytic on a red alga (*Ahnfeltia paradoxa*), sometimes associated with Calothrix and other Lyngbya.

Amami Islands: Yamma, Sumiyo-mura, O-shima, *1749*, 8 Apr. 1955. Koniya, O-shima, *1816 a*, 11 Apr. 1955. Kametsu, Tokuno-shima, *2543*, 14 Jul. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2034 b*, 25 May 1956. Ao-shima, Miyazaki Pref., *2068 a*, *2070 b*, 27 May 1956.

Shikoku: Katsurahama, Kochi, *1402 b*, *1403 b*, *1404 c*, 17 Jun. 1954. Usa, Kochi Pref., *1411 c*, *1413 b*, *1414 b*, *1441 c*, 15–16 Jun. 1954. Cape Muroto, Kochi Pref., *1462 b*, 18 Jun. 1954. O-urasaki near Cape Ashizuri, *1475 b*, 19 Jun. 1954.

Shimonoseki: Yoshimi, *270 c*, *286 b*, *289 b*, 5 Nov. 1950.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1507*, 22 Jun. 1954. *1599 a*, 29 Sept. 1954.

Kii Peninsula: Seto, Shirahama, *442*, 3 Aug. 1951. *519*, 1 Nov. 1951. *549 a*, 2 Nov. 1951. Yuzaki, Shirahama, *496 a*, *501 a*, *502*, *509 a*, 31 Oct. 1951. Hatake-jima, Tanabe Bay, *465 a*, *466 a*, 2 Aug. 1951.

Shima Peninsula: O-shima off Wagu, *760*, 10 Jun. 1952. *805 a*, 5 Oct. 1952. Wagu, *699*, 9 Jun. 1952.

Izu Peninsula: Hamazaki-mura near Shimoda, *843*, *844*, *846*, *847 a*, 8 Oct. 1952. Shimoda, *866*, *876*, 9 Oct. 1952.

Mi-ura Peninsula: Sendagasaki, Kurihama Bay, *999 a*, 28 Mar. 1953. Jyogashima, *1038 a*, *1039 a*, *1040 b*, *1043 b*, *1044*, 30 Mar. 1953.

Boso Peninsula: Kominato, *1062 b*, *1063 a*, *1072 a*, *1077 b*, 3 Apr. 1953.

Matsushima Bay: Yogasaki, *1153 a*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *901*, 28 Oct. 1952. *922 a*, 25 Nov. 1952.

Wakasa Bay: Koiso, Maizuru Bay, *134 b*, 10 Mar. 1950. *417 b*, 8 Jun. 1951. Sanbonmatsu-hana, Maisuru Bay, *147*, 7 Apr. 1950, *1638 b*, *1639 c*, 30 Nov. 1954. Nagahama, Maizuru Bay, *108 b*, 2 Dec. 1949. *1351*, 7 Oct. 1953. *1356*, 23 Oct. 1953. *1363*, 12 Nov. 1953. *1365*, 21 Nov. 1953. *1376*, 28 Dec. 1953. *1383*, 3 Feb. 1954. *1385*, 17 Mar. 1954. *1959 a*, 11 Aug. 1955. Suizu, Tsuruga Bay, *228*, 30 Sept. 1950.

Aomori Pref.: No-ushi, Shimokita Peninsula, *2 b*, Y. Nakamura, 1 May 1949.

Hokkaido: Rebun-to, *1315 b*, *1318 b*, *1320 b*, 31 Jul. 1953. Akkeshi, *1298 d*, 28 Jul. 1953. Muroran, *1241 b*, 15 Jul. 1953.

The filaments of *Lyngbya lutea*, sometimes forming subgelatinous strata on rocks, are densely entangled or twisted together at the base and erect or flexuous above. Among the subgenus Eulyngbya this is one of the species having short and slender filaments, mostly up to 3 mm. or 5 mm. long. The sheath varies in thickness; when young it is very thin, but later becomes in many cases thick and lamellate, sometimes measuring 3μ in thickness. The cross walls of the trichome are generally obscure, especially in those of the basal portion. The granules along the cross walls, which are important for specific determination, occasionally disappear.

Lyngbya lutea is commonly distributed all over the world in marine water as well as in fresh water and thermal water. From some hot springs in Japan it has been reported by Emoto & Hirose (1952), Emoto & Yoneda (1940, 40 a, 42), and Yoneda (1938, 39 a, 42 b, 52 a, 54).

Geographical distribution: Cosmopolitan (on rocks and logs, rarely on other algae in fresh, marine, and thermal waters).

11. **Lyngbya semiplena** (C. Agardh) J. Agardh, Alg. Mar. Medit. et Adriat., p. 11, 1842; Gomont, Journ. de Bot. 4: 354, 1890; Ann. Sci. Nat. VII. Bot. 16: 138, pl. 3, figs. 7–11, 1892; Yoneda, Acta Phytotax. Geobot. 9: 48, fig. 168, 1940; Umezaki, Journ. Jap. Bot. 26: 204, fig. 10, 1951; l. c. 30: 211, 1955; Publ. Seto Mar. Biol. Lab. 2: 246, 1952; l. c. 5: 424, 1956; Bot. Mag. Tokyo 68: 69, 1955; Acta Phytotax. Geobot. 16: 89, 1956.

Plants caespitose, mucous, generally dark yellowish-green or dark green, sometimes becoming dark violet when dried, up to 3 cm. in length or rarely more; filaments decumbent and entwined at the base, above flexuous, 7–15μ in diameter; sheaths hyaline, somewhat mucous, when young homogeneous, becoming lamellate with age, up to 3μ in thickness; trichomes blue-green or yellowish-green, 5–12μ, generally 7–10μ in diameter, apices slightly attenuate or sometimes not; cross walls not constricted, granulate or not; cells 2–3μ in length, 1/3–1/6 as short as the diameter; apical cell with depressed, conical, or round calyptra. Pl. 7, fig. 4.

Japanese name: Yogore-kudamo (nom. nov.).

Habitat: Growing on rocks in the upper or lower littoral belt, or in the

supralittoral belt, sometimes associated with *Hydrocoleum lyngbyaceum*, *Calothrix scopulorum*, *C. crustacea*, and *C. pilosa*, or epiphytic on larger algae.

Amami Islands: Naze, O-shima, *1840 a*, *1841*, 12 Apr. 1955. *2161 a*, *2165*, *2172*, *2174*, *2180*, 24 Jun. 1958. Yamma, Sumiyo-mura, O-shima, *1736*, *1741 a*, *1742 a*, *1743*, 8 Apr. 1955. Koniya, O-shima, *1760*, *1790 c*, *1798 a*, 10 Apr. 1955. Akakina, Kasari-mura, O-shima, *1864 c*, 13 Apr. 1955. Sakihara, Kasari-mura, O-shima, *2451*, *2535*, 11 Jul. 1958. Ankyaba, Kakeroma-to, *2341*, 30 Jun. 1958. So-machi, Kikai-jima, *2389*, 7 Jul. 1958. Kametsu, Tokuno-shima, *2475*, *2482*, *2510*, *2530*, *2531*, 14 Jul. 1958.

Tokara Islands: Takara-jima, *1139 g*, E. Ogata, 27 May 1953. Nakano-shima, *1140 i*, E. Ogata, 5 Jun. 1953.

Kyushu: Cape Kaimon, Kagoshima Pref., *2059 a*, *2062*, *2063 b*, *2064 a*, 26 May 1956. Ushinohama, Kagoshima Pref., *2042 a*, *2051 c*, *2054 a*, 25 May 1956. Ao-shima, Miyazaki Pref., *2067 a*, *2068 b*, *2071 b*, *2079 b*, *2080*, *2081 a*, *2083 c*, *2085 a*, 27 May 1956.

Shimonoseki: Yoshimi, *260 a*, *263 a*, *269 b*, *289 c*, *291 a*, 5 Nov. 1950.

Shikoku: Katsurahama, Kochi, *1402 a*, *1403 a*, *1404 b*, 17 Jun. 1954. Usa, Kochi Pref., *1412 a*, 15 Jun. 1954. Cape Muroto, *1456 b*, *1462 a*, *1463 a*, 18 Jun. 1954. O-urasaki near Cape Ashizuri, *1475 c*, *1476 a*, *1477*, *1485 a*, *1491 a*, 20 Jun. 1954.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1564 d*, 24 Jun. 1954. *1936 b*, 5 Aug. 1955. *1954*, 5 Aug. 1955. Shioya near Kobe, *1589*, S. Mitani, 10 Aug. 1954. Tadano-umi, Hiroshima Pref., *301 b*, *307 b*, 8 Nov. 1950.

Kii Peninsula: Seto, Shirahama, *371 b*, 21 May 1951. *441 b*, *447*, *452 a*, *463 a*, 3 Aug. 1951. *521*, *551 a*, *552*, *555 a*, 1 Nov. 1951. *646 b*, 29 Mar. 1952. *2606*, T. Yamamoto, 1 Jul. 1950. Yuzaki, Shirahama, *497 c*, *498 a*, *500 b*, 31 Oct. 1951. Hatake-jima, Tanabe Bay, *472 b*, 2 Aug. 1951. Wakanoura, Wakayama, *640 b*, 28 Mar. 1952.

Shima Peninsula: Wagu, *713 b*, 9 Jun. 1952. *792*, *794 a*, 4 Oct. 1952. O-shima off Wagu, *623*, 12 Mar. 1952. *815 b*, *823 b*, 5 Oct. 1952. Kashiko-jima, *789*, *790*, *791*, 4 Oct. 1952. Akogi-ura, Tsu, *681*, *682*, *685 a*, *686*, *690*, *691 a*, 7 Jun. 1952.

Izu Peninsula: Shimoda, *864*, *867*, *874*, 9 Oct. 1952. Nagatsuro near Cape Iro, *881 a*, 10 Oct. 1952.

Mi-ura Peninsula: Aburatsubo, *1017 b*, 29 Mar. 1953. Jyoga-shima, *1025 b*, 30 Mar. 1953.

Boso Peninsula: Kominato, *1032 b*, *1075 b*, *1080 b*, *1087 b*, 3 Apr. 1953. Futomi, *1031*, 4 Apr. 1953.

Matsushima Bay: Yogasaki, *1153 b*, 8 Jul. 1953. Katsura-shima, *1166*, *1167 b*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *903 a*, 28 Oct. 1952. *918 b*, 25 Nov. 1952. *926* (as *Phormidium ambiguum* by Umezaki, 1954), *930 b*, 25 Dec. 1952. *1270*, *1272*, 31 Aug. 1953.

Kinosaki: Hiyoriyama near Kinosaki, Hyogo Pref., *2119*, *2120*, 11 Nov. 1956.

Wakasa Bay: Koiso, Sanbonmatsuhana, and Nagahama, Maizuru Bay, *14*, 20 Oct. 1949. *43*, 13 Aug. 1949. *65 b*, 25 Sept. 1949. *88*, 11 Oct. 1949. *108 a*, 2 Dec. 1949. *229 a*, *230 a*, 13 Oct. 1950. *245*, 26 Oct. 1950. *417 a*, 8 Jun. 1951. *487 a*, 23 Aug. 1951. *493 b*, 9 Oct. 1951. *674 a*, 23 May 1952. *965 a*, 2 Mar. 1953. *1130 a*, 27 May 1953. *1358 a*, 4 Nov. 1953. *1576 a*, 22 Jul. 1954. *1581*, *1582 a*, 25 Aug. 1954. *1641 a*, 30 Nov. 1954. *1959 b*, 11 Aug. 1955. *1963 a*, 7 Nov. 1955. *2110 a*, 15 Jun. 1956. *2607*, 30 Apr. 1959. Kato and Obama, Obama Bay, *232*, *233*, *234*, *235*, 14 Oct. 1950. *319 a*, 16 Dec. 1950. Tsunekami, Cape Tsunekami, *474*, 8 Aug. 1951.

Aomori Pref.: Asamushi near Aomori, *1204 a*, 9 Jul. 1953.

Hokkaido: Oshoro, *332 b*, 3 Aug. 1947 (as *Lyngbya Martensiana* by Umezaki, 1952). *1258 a*, 17 Jul. 1953. Rishiri-to, *1347 b*, 3 Aug. 1953.

Lyngbya semiplena, which is widely distributed on the Japanese coast, has been found usually forming pure strata or sometimes associated with other filamentous Cyanophycean species on rocks or on concrete in the supralittoral, upper or lower littoral belts.

Among the species of the subgenus Eulyngbya *L. aestuarii* most resembles *L. semiplena*, but the latter is distinguished by the more slender and simple filaments and by its usually caespitose stratum.

Yoneda (1940) reported this species for the first time for the Japanese flora, on the coast of Beppu, Oita Prefecture, Kyushu, and also from hot springs (1942 b, 52 a).

Geographical distribution: Cosmopolitan (on rocks and larger algae in marine water, rarely in fresh water).

12. **Lyngbya confervoides** C. Agardh, Syst. Algar., p. 73, 1824; Gomont, Journ. de Bot. 4: 354, 1890; Ann. Sci. Nat. VII. Bot. 16: 136, pl. 3, figs. 5, 6, 1892; de Toni, Mem. Real. Istit. Veneto 25: 65, 1895; Holmes, Journ. Linn. Soc. Bot. 31: 257, 1895; Okamura, Synopt. List Jap. Alg. 2nd ed., p. 266, 1916; Matsumura, Index Plant. Jap. 1: 3, 1904; Umezaki, Journ. Jap. Bot. 26: 204, fig. 9, 1951; l. c. 30: 211, 1955; Publ. Seto Mar. Biol. Lab. 2: 246, 1952; l. c. 5: 424, 1956; Bot. Mag. Tokyo 68: 69, 1955; Tanaka, Mem. South. Ind. Sci. Inst. 1: 17, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957.

Lyngbya atrovirens Harvey, Proc. Amer. Acad. 4: 334, 1859; pro synon. in Gomont, l. c. 1892.

Lyngbya atropurpurea Harvey, l. c. 1859; pro synon. in Gomont, l. c. 1892.

Plants caespitose, fasciculate, up to 6 cm. in length, dark yellowish to blackish-green; filaments decumbent and entangled at the base, ascending above, elongate, straight, almost rigid, 12–30μ in diameter; sheaths hyaline, homogeneous, later becoming thick, lamellate and rough on the surface, up to 6μ in thickness; trichomes olive-green or blue-green, 9–25μ, generally 10–16μ in diameter, apices not attenuate; cross walls not constricted, generally granulate, rarely not; cells 2–4μ in length, 1/3–1/8 as short as the diameter; protoplasm granular; apical cell round, withont calyptra. Pl. 8, fig. 2.

Japanese name: Kudamo (nom. nov.).

Habitat: Growing on rocks in the lower or upper littoral belt, sometimes in rock depressions in the supralittoral belt.

Amami Islands: Asani near Naze, O-shima, *1715*, 6 Apr. 1955. Naze, O-shima, *2163*, 24 Jun. 1958. Koniya, O-shima, *1765*, 9 Apr. 1955. Wan, Kikai-jima, *2347*, *2348*, *2349*, 8 Jul. 1958.

Tokara Islands: Nakano-shima, *1140 c*, E. Ogata, 5 Jun. 1953.

Kyushu: Ushinohama, Kagoshima Pref., *2055*, 25 May 1956.

Shikoku: Usa, Kochi Pref., *1439 b*, *1440 a*, *1441 a*, 16 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *517 a*, 1 Nov. 1951. Yuzaki, Shirahama, *495 a*, *497 a*, 31 Oct. 1951. Hatake-jima, Tanabe Bay, *2605*, M. Hiroe, *28* Jun. 1944.

Shima Peninsula: Wagu, *700 c*, 9 Jun. 1952.

Izu Peninsula: Arashidomari near Shimoda, *831*, *836 a*, 8 Oct. 1952. Shimoda, *858 a*, *869*, *877 a*, 9 Oct. 1952. Nagatsuro near Cape Iro, *880 a*, 10 Oct. 1952.

Wakasa Bay: Nagahama, Maizuru Bay, *212*, 17 Aug. 1950.

The plants from Ushinohama, Kagoshima Prefecture, have filaments 3–4 cm. long and 24–28μ broad, sheaths 3–5μ thick, and trichomes 16–18μ broad. In the specimens from Arashidomari, near Shimoda, Izu Peninsula, the plants are typical in their characteristics—the filaments are 4–6 cm. long and 18–22μ broad, the sheaths 2.5–5μ thick, and the trichomes 14–18μ broad. At Koniya, O-shima, Amami Islands, I have collected a large floating plant which is coloured rose-violet and has typical filaments.

The type locality of *L. confervoides* C. Ag. (1824) is Cadiz, Spain. This cosmopolitan species is especially common in the warmer seas. On the Japanese coast it has been commonly found on the southern coasts. From Wakasa Bay on the Japan Sea coast, the northernmost for this species, it was collected only one time during the summer season of 1950.

Harvey (1859) reported the occurrence of this species, under the name of *Lyngbya atrovirens* Harv. and *L. atropurpurea* Harv., from Ryukyu and Bonin Islands, on the basis of C. Wright's collections; and these two names were placed as synonyms of *L. confervoides* by Gomont (1892). G. de Toni (1895) reported Gomont's disposition of these names in his "Phyceae Japonicae novae."

Geographical distribution: Cosmopolitan (on rocks in marine water).

13. **Lyngbya majuscula** (Dillwyn) Harvey seq. Gomont, Ann. Sci. Nat. VII. Bot. 16: 131, pl. 3, figs. 3, 4, 1892; Umezaki, Journ. Jap. Bot. 26: 205, fig. 12, 1951; l. c. 30: 211, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 71, pl. 5, fig. 2, 1953; Publ. Seto Mar. Biol. Lab. 5: 423, 1956; Tanaka, Mem. South. Ind. Sci. Inst. 1: 17, 1956; Dawson, Pac. Naturalist 1 (5): 29, 1959.

Plants caespitose, forming a widely expanded, brown or dark blue-green stratum, up to 7 cm. in length; filaments very elongate, wavy, circinate or slightly flexuous, 24–65μ in diameter; sheaths hyaline, when young thin, not lamellate, later becoming very wide, lamellate and rough on the surface, up to 12μ or 15μ in thickness; trichomes blue-green or dull green, 15–35–(43.5)μ in diameter, apices not attenuate; cross walls not granulate, not constricted; cells very short, 2–4μ in length, 1/5–1/15 as short as the diameter; protoplasm finely granular; apical cell round, without calyptra. Pl. 8, fig. 3.

Japanese name: O-kudamo (nom. nov.).

Habitat: Growing on rocks or sand in the upper littoral or supralittoral belt, or in the lower littoral belt, sometimes on larger algae (Halimeda, Caulerpa, Acanthophora, Spyridia, and Corallina), rarely floating.

Amami Islands: Koniya, O-shima, *1823*, 11 Apr. 1955. Tean near Koniya, O-shima, *2185*, *2186*, *2187*, *2191*, *2196*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2209*, *2210*, *2212*, *2214*, *2218*, *2248*, *2284*, *2285*, *2287*, *2295*, *2303*, *2307*, *2309*, *2311*, *2312*, *2313*, 28 Jun. 1958. Kunetsu near Koniya, O-shima, *2217*, Y. Yoneda, 30 Jun. 1958. Kasari, O-shima, *2252*, *2266*, *2271*, *2274*, *2279*, Y. Yoneda, 11 Jul. 1958. Ankyaba, Kakeroma-to, *2315*, *2316*, *2324*, *2481*, 30 Jun. 1958. Urasokari near Koniya, O-shima, *2541*, 1 Jul. 1958. Ushuku and Sakihara, Kasari-mura, O-shima, *2428*, *2430*, *2433*, *2437*, *2455*, *2460*, 10-11 Jun. 1958. Ikeji, Kikai-jima, *2367*, *2373*, 6 Jul. 1958. So-machi, Kikai-jima, *2388*, 7 Jul. 1958. Wan, Kikai-jima, *2407*, 8 Jul. 1958. Kametsu, Tokuno-shima, *2503*, *2516*, *2520*, *2521*, 14-15 Jul. 1958.

Shikoku: Katsurahama, Kochi, *1443*, *1447 b*, 16 Jun. 1954.

Shima Peninsula: O-shima off Wagu, *826 a*, 5 Oct. 1952.

Boso Peninsula: Kominoto, *1090*, 3 Apr. 1953.

Wakasa Bay: Kato, Obama Bay, *99*, 22 Jun. 1949. Kanmuri-jima off Maizuru Bay, *35*, 23 Jul. 1949. Suizu, Tsuruga Bay, *202*, 5 Aug. 1950.

The plants of *Lyngbya majuscula* were very abundantly collected on the Amami Islands when I visited in June-July, 1958 and their characteristics are typical; while at other areas on the Japanese coast it was rare and the plants are generally dwarf in growth.

In Harvey's manuscript, which was recently published by Dawson (1959), this species (as *Lyngbya majuscula* (Ag.)) is described as occurring on Ryukyu Island.

The species was recorded from fresh and thermal waters of Japan by Emoto & Hirose (1952), Emoto & Yoneda (1940, 41), and Yoneda (1938, 50, 52 a).

Geographical distribution: Cosmopolitan (on rocks and other algae, or rarely floating in marine water, rarely in fresh or thermal waters).

Genus 8. **Symploca**

Kuetzing, Phyc. Gener., p. 201, 1843; Phyc. Germ., p. 167, 1845; Spec. Algar., p. 270, 1849; Gomont, Ann. Sci. Nat. VII. Bot. 16: 104, 1892.—Type species: *S. meneghiniana* Kuetz.

Plants prostrate at the base, ascending and in erect or rarely more or less procumbent, densely jointed, anastomosing fascicles; filaments vaginate, generally branched; branches solitary; sheaths thin, hyaline, firm or somewhat mucous; trichomes sometimes constricted at cross walls, apices with slightly thickened membranes.

Key to species of Symploca:

1. Trichomes 3.5-8.5-(9)μ in diameter; apical cell without calyptra ..... 1. *S. hydnoides*
1. Trichomes 4-5.5μ in diameter; apical cell with calyptra. ..... 2. *S. atlantica*

1. **Symploca hydnoides** Kuetzing, Spec. Algar, p. 272, 1849; Tab. Phyc., I, p. 44, tab. 76, fig. 2; Gomont, Journ. de Bot. 4: 354, 1890; Ann. Sci. Nat. VII. Bot. 16: 106, pl. 2, figs. 1-4, 1892; Umezaki, Journ. Jap. Bot. 31: 35, fig. 42 A, 1956; Publ. Seto Mar. Biol. Lab. 5: 426, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957; Tanaka, Mem. South. Ind. Sci. Inst. 1: 17, 1956.

Hypheothrix involvens Kuetzing, Spec. Algar., p. 269, 1849; Tab. Phyc., I, p. 42, tab. 71, fig. 3.

Symploca fasciculata Kuetzing, Spec. Algar., p. 269, 1849; Tab. Phyc., I, p. 43, tab. 75, fig. 4.

Plants variable in shape, soft fasciculate-caespitose, cartilaginous, fasciculate-pyramidal, spiny, Phormidium-like, or branched, deep olive-green or dark lead-coloured; filaments compactly aggregate, sparsely branched, 6–9–(11)μ in diameter; sheaths hyaline, thin, slightly mucous; trichomes blue-green, 4.5–8.5–(9)μ in diameter, often slightly constricted at the cross walls near apices; apices straight, not attenuate; cells 4.5–13μ in length; protoplasm large- or fine-granular; apical cell slightly inflated or round, sometimes with a slightly thickened outer-membrane, without calyptra. Pl. 9, fig. 1.

Habitat: Growing on rocks in the lower or upper littoral belt, or rarely in the infralittoral belt, sometimes on larger plants and algae (marine phanaerogams, Codium, Acetabularia, Digenea, and Hypnea).

Amami Islands: Asani near Naze, O-shima, *1702*, *1705*, 6 Apr. 1955. Naze, O-shima, *1849*, 12 Apr. 1955. *2164*, *2201*, 24 Jun. 1958. Akakina, Kasari-mura, O-shima, *1863*, 13 Apr. 1955. *2508*, 12 Jul. 1958. Seisui near Koniya, O-shima, *2207*, *2211*, *2297*, *2305*, 29 Jun. 1958. Tean near Koniya, O-shima, *2192*, 28 Jun. 1958. Koniya, O-shima, *1764 b*, *1766*, *1770*, *1771*, *1812*, *1819*, *1821*, *1830*, *1832*, *1834*, *1857 a*, *1858*, 9–11 Apr. 1955. Gusuku, Sumiyo-mura, *1718*, 7 Apr. 1955. Katetsu near Koniya, O-shima, *2216*, Y. Yoneda, 29 Jun. 1958. Ankyaba, Kakeroma-to, *2469*, *2497*, 30 Jun. 1958. Kametsu, Tokuno-shima, *2488*, 14 Jul. 1958.

Kyushu: Shingu and Tsuyasaki, Fukuoka Pref., *1968*, *1990*, *1999*, 20–21 May 1956.

Shikoku: Usa, Kochi Pref., *1437 a*, 16 Jun. 1954. Tsuro near Cape Ashizuri, *1490*, 20 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1511*, *1520*, *1521*, *1523*, *1524 a*, 23 Jun. 1954. *1911*, *1913*, 5 Aug. 1955. Hon-jima, Shiaku Islands, *1534*, *1536 a*, *1537*, *1538*, *1539*, *1547 a*, *1553 c*, *1557*, *2563*, *1567*, *1572*, 23–24 Jun. 1954. *1604 a*, *1605*, *1606*, *1609 a*, 29 Sept. 1954. *1616*, *1618*, 30 Sept. 1954. *1907*, *1910*, *1920*, *1921*, *1922 a*, *1940*, *1941*, *1942*, *1943*, 6 Aug. 1955.

Kii Peninsula: Seto, Shirahama, *373 a*, *381 a*, *393 a*, *400*, *403*, 21–22 May 1951. *632*, T. Yamamoto, 15 Sept. 1951. *755 b*, 9 Jun. 1952. *2693*, 8 Jun. 1960.

Shima Peninsula: Wagu, *700 b*, *708 b*, *720*, 9 Jun. 1952. O-shima off Wagu, *721 b*, *722*, *723*, *743*, 10 Jun. 1952. Goza, *746*, 11 Jun. 1952.

Matsushima Bay: Katsura-shima, *1158 a*, *1160*, 8 Jul. 1953.

Wakasa Bay: Kato, Obama Bay, *11*, 25 Jun. 1949. *320*, *321*, 16 Dec. 1950. *356*, 1 Feb. 1951. *422 a*, 21 Jun. 1951. *424*, 21 Jun. 1951 (as *Symploca muscorum* by Umezaki, 1953 a). *562 a*, *565*, 10 Nov. 1951. *582*, 2 Mar. 1952. *935*, 31 Dec. 1952. *946 a*, 25 Jan. 1953. *971 b*, 15 Mar. 1953. Takahama, Fukui Pref., *347*, *349*, *353*, 31 Jan. 1951. Tagarasu near Obama, *115 d*, 23 Dec. 1949 (as *Symploca muscorum* by Umezaki, 1953 a).

Aomori Pref.: Asamushi near Aomori, *1194*, 9 Jul. 1953.

Symploca hydnoides Kuetz. (Spec. Algar., p. 272, 1849), which was described by Kuetzing, on the basis of Lenormand's specimens, nos. 194 and 342, and Carmichael's *Scytonema hydnoides* Carm., was placed as a representative name for this species in his "Monographie des Oscillariées" by Gomont (1892), although there were some

earlier species. I have also used the name in accordance with Gomont's decision.

Variously shaped plants have been found in the Japanese waters: soft fasciculate-caespitose plants, cartilaginous fasciculate pyramidal plants, cartilaginous fasciculate-spine-shaped plants, phormidioid plants, and slender branched plants up to 1 cm. long. Of them the soft fasciculate-caespitose plants have been collected on the Amami Islands and Kii Peninsula; slender branched plants only on the Amami Islands; cartilaginous fasciculate-pyramid plants on the Amami Islands, Kyushu, Shikoku, Seto Inland Sea, Kii Peninsula, and Shima Peninsula; cartilaginous fasciculate-spine-shaped plants on the Amami Islands, Kyushu, Seto Inland Sea, Kii Peninsula, Wakasa Bay, and Aomori Prefecture; and phormidioid plants on the Amami Islands, Seto Inland Sea, Kii Peninsula, Shima Peninsula, Matsushima Bay, and Wakasa Bay. Whether such plant-shapes are of taxonomic value or are the result of different ecological conditions is a difficult problem; further study is desired. (See Pl. 9, fig. 1 a).

I have examined authentic specimens, Lenormand's nos. 194 and 342 (both slide specimens in Rijksherbarium at Leiden) and the types of *Hypheothrix involvens* Kuetz. (Spec. Algar., p. 269, 1849, in Rijksherbarium at Leiden) and of *Symploca fasciculata* Kuetz. (Spec. Algar., p. 269, 1849, in Rijksherbarium at Leiden) and have learned that all the specimens examined are soft fasciculate-caespitose and that they closely resemble my collections, 632 and 1705, in regard to the shape of plant. Lenormand's no. 194 plant is 10 mm. long, no. 342 19 mm. long, the type of *Hypheothrix involvens* 8 mm. long, and the type of *Symploca fasciculata* broken; these specimens are a little shorter than my specimens (nos. 632 and 1705), which measure 3–4 cm. long. In the authentic and type specimens the trichome is 5.5–9μ in diameter, while that of the Japanese plants is 4.5–8.5–(9)μ, a little slender.

Geographical distribution: Cosmopolitan (on rocks and larger algae in marine water).

2. **Symploca atlantica** Gomont, Ann. Sci. Nat. VII. Bot. 16: 109, pl. 2, fig. 5, 1892.

Plants expanded, thick, dark blue-green; filaments densely entangled, unbranched, angular, 6–6.5μ in diameter; sheaths hyaline, thin, firm; trichomes blue-green, 4–5.5μ in diameter; cross walls constricted, slightly pellucid; cells 2.5–6μ in length, quadrate or a little shorter than the diameter; apical cell round or conical, with calyptra. Pl. 9, fig. 2,

Habitat: Growing on concrete in the upper littoral belt.

Matsushima Bay: Yogasaki, *1154*, 8 Jul. 1953.

The present plants seem to be young, for the apical cells of the trichomes have sometimes no thickened calyptra like those of the typical form. Matsushima Bay is the only locality for this species on the Japanese coast.

Geographical distribution: On rocks and larger algae in marine water. Atlantic

coast of Europe (France, Spain, British Isles); Mediterranean (France); Atlantic coast of North America (Florida).

Subtribe 2. **Oscillarinae**

Gomont, Journ. de Bot, 4: 355, 1890; Ann. Sci. Nat. VII. Bot. 16: 156, 1892.

Filaments unbranched; sheaths thin, always hyaline, mucous, more or less diffluent, absent in many species or not apparent; trichomes cylindrical, apices oblong or attenuate, in some species curved.

Genus 9. **Phormidium**

Kuetzing, Phyc. Gener., p. 190, 1843; Gomont, Ann. Sci. Nat. VII. Bot. 16: 156, 1892. —Type species: *P. inundatum* Kuetz.

Plants forming wooly or felt-like layers or rarely floating; filaments unbranched; sheaths thin, hyaline, enclosing a single trichome, mucous, agglutinated, partly or entirely diffluent; trichomes cylindrical, in some species constricted at the cross walls, apices often attenuate, straight or curved; apical cell capitate or not, in many species the outer membrane thickened into a calyptra.

Key to species of Phormidium:

Section 1. **Moniliformia.** Trichomes distinctly torulose, apices neither curved nor capitate.

1. Plants bright blue-green; trichomes 2.7-3.5μ in diameter ..... 1. *P. molle*
1. Plants rose-colour; trichomes 1.3-2.5μ or 3μ in diameter ..... 2. *P. Ectocarpii*

Section 2. **Euphormidia.** Trichomes rarely or scarcely torulose, apices straight or curved, in many species capitate.

1. Trichomes 1-2.5μ in diameter 2
1. Trichomes 3-6μ in diameter 3
2. Plants gelatinous, membranaceous; trichomes 1-2μ in diameter. ..... 3. *P. tenue*
2. Plants cartilaginous, pulvinate; trichomes 1.5-2.5μ in diameter ..... 4. *P. Crosbyanum*
3. Apical cell of trichome not capitate ..... 5. *P. corium*
3. Apical cell of trichome capitate or subcapitate. 4
4. Plants epiphytic ..... 6. *P. Feldmannii*
4. Plants not epiphytic 5
5. Trichomes 3-5μ in diameter; cells 3-6μ in length ..... 7. *P. submembranaceum*
5. Trichomes 5-6μ in diameter; cells 6-15μ in length ..... 8. *P. penicillatum*

Section 1. **Moniliformia**

Gomont, Ann. Sci. Nat. VII. Bot. 16: 159, 1892.

Trichomes distinctly torulose, apices neither curved nor capitate.

1. **Phormidium molle** (Kuetzing) Gomont, Ann. Sci. Nat. VII. Bot. 16: 163, pl 4, fig. 12, 1892.

Plants bright blue-green, thin, membranaceous; filaments intricate; sheaths hyaline, conspicuous, not diffluent; trichomes blue-green, straight or intricate, 2.7–3.5μ in diameter, apices not attenuate; cross walls constricted, not granulate; cells

3-8μ in length, from nearly quadrate to 2-2.5 times as long as the diameter; apical cell round, without calyptra. Pl. 9, fig. 3.

Habitat: Growing on the wall of a glass-vessel in which marine water had been placed for other algal culture, associated with *Phormidium tenue*.

Wakasa Bay: Maizuru, in a laboratory of the Department of Fisheries, Faculty of Agriculture, Kyoto University, *1694 a*, 25 Feb. 1955.

In the material at hand, the cross walls of the trichome are not so conspicuously pellucid as in Gomont's figure (1. c.); but they are slightly constricted, and the sheaths are generally firm, never diffluent.

This species was reported as occurring in thermal water and in terrestrial habitats by Yoneda (1942, 42 a, 52 a).

Geographical distribution: In fresh water, often terrestrial, rarely in marine water. Atlantic coast of Europe (France); Indian Ocean (Madagascar); West Indies (Bonaire Island).

2. **Phormidium Ectocarpii** Gomont, Bull. Soc. Bot. de Fr. 46: 37, pl. 1, fig. 13, 1899; Umezaki, Journ. Jap. Bot. 26: 268, fig. 14, 1951.

Plants soft-membranaceous, rose-coloured; filaments fragile, straight or slightly curved, 3-4μ in diameter; sheaths hyaline, obscure or sometimes distinct, diffluent; trichomes pale purple or light yellow, 1.3-2.5μ or 3μ in diameter, apices not attenuate; cross walls constricted, pellucid, without granules; cells a little longer or a little shorter than the diameter; apical cell round; protoplasm homogeneous. Pl. 9, fig. 4.

Habitat: Growing on the wall of a glass-vessel in which marine water had been placed for other algal culture.

Wakasa Bay: Maizuru, in a laboratory of the Department of Fisheries, Faculty of Agriculture, Kyoto University, *60*, Sept. 1949.

The type of *Phormidium Ectocarpii* from Plymouth, England, collected by E. A. Batters, was described by Gomont on Ectocarpus and mud in marine water. The Japanese specimen was found on the wall of a glass-vessel in which salt water from Maizuru Bay had been placed for the culture of other algae, forming soft-membranaceous strata, coloured rose as in the type.

Since some trichomes are a little thicker than those of the original description, measuring 3μ in diameter, and the apical cells are usually rounded, this material seems to be rather near to the f. *fuscescens* Frémy which was described by A. Nasr (1941) who distinguished it from the typical form by its round apical cell, by its stratum with brownish-red colour, and by the dimension of the trichomes (2.5-2.6μ in diameter). Notwithstanding, I have referred this specimen to *P. Ectocarpii* f. *Ectocarpii* rather than to f. *fuscescens* for the reason that this plant is rose-coloured instead of brownish-red and that most of the trichomes are as large as 2.5μ in diameter. Lindstedt (1943) reported that the colour of the plant of this species is

hardly affected by changing the intensity of light.

Geographical distribution: In marine water. Atlantic coast of Europe (Sweden, Denmark, France, British Isles); Red Sea.

Section 2. **Euphormidia**

Gomont, Ann. Sci. Nat. VII. Bot. 16 : 159, 1892.

Trichomes rarely or scarcely torulose, apices straight or curved, in many species capitate.

3. **Phormidium tenue** (Meneghini) Gomont, Ann. Sci. Nat. VII. Bot. 16 : 169, pl. 4, figs. 23–25, 1892; Umezaki, Journ. Jap. Bot. 30 : 210, fig. 2 A, 1955.

Plants expanded, thin, membranaceous, bright blue-green or pale blue-green; filaments densely intricate, elongate; sheaths hyaline, thin, mostly diffluent; trichomes pale blue-green, 1–2μ in diameter, apices straight or curved, attenuate or not; cross walls slightly constricted, not granulate, pellucid; cells 2.5–5μ in length, 1.5–3 times as long as the diameter; protoplasm homogeneous; apical cell acute-conical or round, without calyptra. Pl. 9, fig. 5,

Habitat: Growing on rocks in the upper littoral belt, or in a glass-vessel in which salt water had been placed.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1918 a*, 5 Aug. 1955.

Shima Peninsula: Wagu, *701 a*, 9 Jun. 1952 (as *Phormidium Crosbyanum* by Umezaki, 1954, 55 a). Matoya, Motoya Bay, 829, 6 Oct. 1952.

Matsushima Bay: Shiogama, *1151 c*, 7 Jul. 1953.

Wakasa Bay: Nagahama, Maizuru, *81*, 30 Sept. 1949. *776*, 28 Aug. 1952. *1694 b*, 25 Feb. 1955.

Some specimens of this species were found in glass-vessels in which salt water had been placed for the culture of other algae; they usually formed thin, membranaceous bright blue-green strata of the typical form as in that of the fresh water habitats, whereas those found on rocks were not so well developed as in the typical form. The sheaths are diffluent in many cases, so that most of the trichomes are naked. The apical cells of the trichomes are diverse in shape, sometimes round or sometimes typically acute-conical. The cross walls of the trichomes are so transparent that the limits of each cell are readily recognized.

The specimens from Shima Peninsula which were referred to *Phormidium Crosbyanum* (by Umezaki, 1954, 55 a) are here determined as *P. tenue* to which they are closely related.

This species is commonly distributed in Japanese thermal and fresh waters and was reported by many phycologists (Emoto & Hirose 1940, 40 a, b, 41 a, 42 a, 49; Emoto & Yoneda 1940 a, 41 a, 42; Fukushima 1952; Molisch 1926; Yoneda 1937, 38 a, 42 a, b, c, d, 52, 52 a).

Geographical distribution: Cosmopolitan (in fresh, thermal, or rarely marine waters, or terrestrial).

4. **Phormidium Crosbyanum** Tilden, Minnesota Alg. 1 : 96, pl. 4, figs. 60, 61, 1910; Drouet, Field Mus. Nat. Hist. Bot. Ser. 20 : 119, 1942.

Plants pulvinate, 2–4 cm. in diameter, 1–2 cm. in thickness, pale brown or brownish-green, cartilaginous, slightly impregnated with lime; filaments intricated below, parallel above; sheaths hyaline, delicate; trichomes pale aeruginous, 1.5–2.5μ in diameter, apices straight, not attenuate; cross walls not constricted, without granules; cells 4–6μ in length, 3–4 times as long as the diameter; apical cell round, without calyptra. Pl. 10, fig. 4.

Habitat: Growing on rocks in the lower or upper littoral belt, or along high tide level.

Amami Islands: Kasari, O-shima, *2254*, Y. Yoneda, 10 Jul. 1958. Ushuku, Kasari-mura, O-shima, *2436*, 10 Jul. 1958. So-machi, Kikai-jima, *2396*, 7 Jul. 1958.

Phormidium Crosbyanum, a tropical species, has been found only on the Amami Islands. The plants grow somewhat firmly attached to rocks with their flattened basal parts. The cushion-shaped plants are cartilaginous like those of Symploca, and their outer surfaces are pale brown or brownish-green; their inner parts in which dead, colourless filaments and empty sheaths are very densely crowded are sometimes discoloured. The trichomes are 1.5–2.5μ, mostly 2–2.5μ in diameter, a little broader than those of other foreign specimens, and their cells are 4–6μ in length.

Geographical distribution: On rocks in marine water. West Indies (Jamaica, Bahamas, Puerto Rico, Cuba, Tobago, Haiti); Central America (Panama); Pacific Ocean (Hawaiian Islands, Marshall Islands); Southeast Asia (Philippines).

5. **Phormidium corium** (Agardh) Gomont, Ann. Sci. Nat. VII. Bot. 16 : 172, pl. 5, figs. 1, 2, 1892; Umezaki, Journ. Jap. Bot. 26 : 268, fig. 15, 1951; Acta Phytotax. Geobot. 16 : 88, 1956; Publ. Seto Mar. Biol. Lab. 5 : 422, 1956.

Plants widely expanded, thin, membranaceous, dark blue-green; filaments densely intricate, elongate, flexuous; sheaths thin, mostly diffluent, hyaline; trichomes blue-green or yellowish-green, 3–5μ in diameter, apices straight, briefly attenuate or not; cross walls not constricted, not granulate; cells 3–8μ in length, 1–2 times as long as the diameter; protoplasm homogeneous or sometimes granular; apical cell obtuse-conical or nearly round, without calyptra. Pl. 9, fig. 6.

Habitat: Growing on rocks or concrete in the lower or upper littoral belt.

Amami Islands: Koniya, O-shima, *1783 b*, 10 Apr. 1955. Yamma, Sumiyo-mura, O-shima, *1738 b*, 8 Apr. 1955.

Tokara Islands: Nakano-shima, *1140 a*, E. Ogata, 5 Jun. 1953.

Kyushu: Ushinohama, Kagoshima Pref., *2040*, 25 May 1956.

Kii Peninsula: Yuzaki, Shirahama, *497 b*, 31 Oct. 1951.

Amino: Amino Bay, Kyoto Pref., *782 b*, 24 Sept. 1952.

Hokkaido: Muroran, *329*, 20 Jul. 1947. Akkeshi, *1297 b*, 28 Jul. 1953.

Phormidium corium occurs commonly in fresh water, sometimes in thermal and marine waters. On our coasts the species has been found at several localities, but

the specimens are all scanty. On the other hand, in hot springs of Japan the species is common and has been reported by many persons (Emoto & Hirose 1940, 40 b, 42 b, 48, 49; Emoto & Yoneda 1940, 40 a, 41 a, 42; Molisch 1926; Yoneda 1938, 38 a, 39 a, 41 b, 42 a, b, c, 52, 52 a, 54).

Geographical distribution: Cosmopolitan (in fresh, thermal or marine waters, or aerophytic).

6. **Phormidium Feldmannii** Frémy in Feldmann, Rev. Algol. 9: 157, fig. 4, 1937.

Plants growing in the cortical layers of Codium plants; filaments elongate, flexuous, up to 5 mm. in length; sheaths hyaline, thin, sometimes diffluent; trichomes brownish-blue-green, ca. 5μ in diameter, apices slightly attenuate or not, straight; cross walls not constricted, not granulate; cells nearly quadrate or a little longer than the diameter, 4.5–9μ or 12μ in length; protoplasm granular; apical cell with a rounded- conical calyptra. Pl. 10, fig. 1.

Habitat: Growing on *Codium adhaerens*.

Kii Peninsula: Seto, Shirahama, *411 b*, 22 May 1951.

The type of *Phormidium Feldmannii*, found with *Microcoleus Voukii* in the layer of *Codium bursa*, was collected by J. Feldmann at Banyuls, France, and described by Frémy in Feldmann's "Les algues marines de la côte de Albéres."

So far as I know the species has never been found from another locality since it was described. On our coasts Seto, Shirahama, Kii Peninsula, is the only locality for the species. Except for the brownish-blue-green colour of the trichome instead of violet-purple, the characteristics well agree with the original diagnosis.

Geographical distribution: On Codium. Mediterranean (France).

7. **Phormidium submembranaceum** (Ardissone & Strafforello) Gomont, Ann. Sci. Nat. VII. Bot. 16: 180, pl. 5, fig. 13, 1892.

Plants dark green, thick-membranaceous; filaments intricate in an amorphous mucous; sheaths hyaline, mostly diffluent; trichomes 3–5μ in diameter, apices straight, long, and gradually attenuate; cross walls slightly constricted, not granulate, sometimes slightly pellucid; cells 3–6μ in length, nearly quadrate or a little longer than the diameter; protoplasm homogeneous or densely granular; apical cell capitate, with a depressed-conical calyptra. Pl. 10, fig. 3.

Habitat: Growing on rocks in the upper littoral belt.

Shima Peninsula: Akogi-ura, Tsu, *689*, 7 Jun. 1952.

Mi-ura Peninsula: Jyogashima, *1023*, 30 Mar. 1953.

Phormidium submembranaceum is a strictly marine species of this genus, the majority of species of which grow in fresh or thermal waters, or in terrestrial or aerophytic habitats.

In the specimen from Shima Peninsula the cells are 3–4.5μ in diameter and 3–5μ in length, the measurements being a little slender and shorter than those of

Gomont's description. But, the material from Mi-ura Peninsnla is typical; the cells are 4.5–5μ broad and 3–6μ long.

Geographical distribution: On rocks in marine water. Atlantic coast of Europe (France); Mediterranean (Italy); Atlantic coast of North America (Florida, Maine); Pacifiic coast of North America (California).

8. **Phormidium penicillatum** Gomont, Bull. Soc. Bot. de Fr. 40 : 87 pl. 4, figs. 5–7, 1893; Umezaki, Bot. Mag. Tokyo 68: 67, 1955.

Plants yellowish-brown, brush-shaped or gelatinous cushion-shaped, attached at the base and irregularly splitting at the upper portion; filaments elongate, fasciculate, suberect, 6–7μ in diameter; sheaths hyaline, mostly diffluent; trichomes blue-green, 5–6μ in diameter, apices scarcely attenuate; cross walls slightly constricted or not, not granulate; cells 6–15μ in diameter, nearly quadrate or up to 2.5 times as long as the diameter; protoplasm granular; apical cell truncate or subcapitate, with a slightly thickened outer-wall. Pl. 10, fig. 2.

Habitat: Growing on rocks or corals, sometimes in tide pools, in the upper littoral belt.

Amami Islands: Sakihara, Kasari-mura, O-shima, *2448*, *2454*, 11 Jul. 1958. Ikeji, Kikai-jima, *2360*, *2362*, 6 Jul. 1958. Wan, Kikai-jima, *2418*, *2425*, 8 Jul. 1958. Kametsu, Tokuno-shima, *2519*, 14 Jul. 1958.

Tokara Islands: Takara-jima, *1139 d*, E. Ogata, 27 May 1953.

Phormidium penicillatum has been found only from the Islands of Amami and Tokara, where the alga was very luxuriant in growth. The plants from the Amami Islands are distinguished in two forms in shape: One is typical brush-shaped; and the other is gelatinous, round, cushion-shaped. The plants of the latter form were abundant in growth. The characteristics of the plants of both forms, except for the shape of plant, are same together.

Geographical distribution: On rocks in marine water. West Indies (Jamaica, Puerto Rico); Pacific Ocean (Marshall Islands); Indian Ocean (Mascarene Islands); Atlantic coast of North America (Florida); Red. Sea.

Genus 10. **Arthrospira**

Stizenberger, Hedwigia 1 : 32, 1852; Gomont, Ann, Sci. Nat. VII. Bot. 16 : 246, 1892. —Type species: *A. Jenneri* Stiz.

Trichomes cylindrical, evaginate, twisted in very regular, more or less loose spirals, apices sometimes attenuate; cross walls distinct; apical cell round, without calyptra.

One species:

Arthrospira miniata (Hauck) Gomont, Ann. Sci. Nat. VII. Bot. 16 : 248, 1892.

Plants forming a mucous, membranaceous, brown stratum; trichomes blue-green, 2.5–3μ in diameter, twisted in a very loose spiral 4–5μ in diameter and

12–18μ in distance between the turns, apices slightly attenuate or not, or sharply attenuate; cross walls not constricted, not granulate; cells 3.5–9–(12)μ in length, nearly quadrate or up to 3 times as long as the diameter; apical cell not capitate or subcapitate; protoplasm homogeneous.

In the Japanese specimens the cells are generally long, measuring 3.5–9μ or 12μ; while according to the original description of this species they are 3.5–7μ.

Key to forms of *Arthrospira miniata*:

1. Apices of trichomes slightly attenuate or not..... f. *miniata*
1. Apices of trichomes sharply attenuate..... f. *acutissima*

f. **miniata**

Apices of trichomes slightly attenuate or not. Pl. 10, fig. 5.

Habitat: Growing on corals along high tide level, associated with *Oscillatoria nigro-viridis*.

Amami Islands: Ikeji, Kikai-jima, *2377*, 6 Jul. 1958.

The trichomes are gradually attenuated and slightly capitated at their apices; sometimes they are not attenuated and their apical cell is round, not capitated.

Geographical distribution: In marine water. Atlantic coast of Europe (France); Mediterranean (Adriatic Sea, Dalmatian coast, France); West Indies.

f. **acutissima** Umezaki, f. nov.

Trichomatibus ad apices acutissime attenuatis. (v.v.s.). Pl. 10, fig. 6.

Habitat: Growing on rocks, or epiphytic on *Codium intricatum*.

Kii Peninsula: Seto, Shirahama, on rocks in the upper littoral belt, *384*, 23 May 1951 (Type). *407*, 22 May 1951 (Iso-type).

Kyushu: Tomioka, Amakusa, *2025*, 24 May 1956.

This new form is characterized by the point that the trichomes are sharply attenuated at their apices.

Genus 11. **Spirulina**

Turpin seq. Gomont, Ann. Sci. Nat. VII. Bot. 16: 249, 1892.—Type species: *S. oscillarioides* Turpin.

Plants solitary or forming thin, mucous, membranaceous strata; trichomes cylindrical, evaginate, twisted in a regular, more or less loose or close spiral, apices not attenuate; cross walls obscure; protoplasm homogeneous or finely granular.

Key to species of Spirulina:

1. Spirals loosely twisted..... 2
1. Spirals tightly twisted..... 3
2. Trichomes 0.4–0.6μ in diameter; spirals 1.2–1.6μ in diameter..... 1. *S. tenerrima*
2. Trichomes 1μ in diameter; spirals 3μ in diameter..... 2. *S. major*
3. Trichomes 1–2μ in diameter; spirals regular or irregular, 3–5μ in diameter..... 3. *S. subsalsa*
3. Trichomes 1μ in diameter; spirals regular, 2–2.7μ in diameter..... 4. *S. labyrinthiformis*

1. **Spirulina tenerrima** Kuetzing, Phyc. Gener., p. 183, 1843; Tab. Phyc., I, p. 25, tab. 37, fig. 1; Spec. Algar., p. 235, 1849; Gomont, Ann. Sci. Nat. VII. Bot. 16: 252, 1892; Drouet, Field Mus. Nat. Hist. Bot. Ser. 20: 13, 1939; l. c. 20: 122, 1942; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 420, 1956.

Spirulina socialis Gardner, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Isl. 8: 272, pl. 1, fig. 1, 1932; Umezaki, Journ. Jap. Bot. 27: 221, fig. 22, 1952; l. c. 30: 209, 1955; Bot. Mag. Tokyo 68: 66, 1955; Publ. Seto Mar. Biol. Lab. 2: 243, 1952.

Plants mixed sparsely with other Cyanophycean species; trichomes 0.4–0.6μ in diameter, twisted into very regular spirals with a diameter of 1.2–1.6μ; distance between coils 1–1.5μ; cross walls indistinct; protoplasm pale blue-green, homogeneous. Pl. 10, fig. 7.

Habitat: Growing on the sheaths of Hydrocoleum (*H. lyngbyaceum*, *H. glutinosum*, and *H. cantharidosmum*).

Amami Islands: Yamma, Sumiyo-mura, O-shima, *1745 b*, *1750 b*, 8 Apr. 1955. Ushuku, Kasari-mura, O-shima, *1855 e*, 13 Apr. 1955. Sakihara, Kasari-mura, O-shima, *2459*, 11 Jul. 1958. Ikeji, Kikai-jima, *2359*, 6 Jul. 1958. Wan, Kikai-jima, *2412*, 8 Jul. 1958.

Tokara Islands: Takara-jima, *1139 n*, E. Ogata, 27 May 1953 (as *Spirulina socialis* by Umezaki, 1955).

Kyushu: Shingu, Fukuoka Pref., *1969 b*, *1971 c*, 20 May 1956.

Shikoku: Usa, Kochi Pref., *1429 c*, *1430 d*, *1431 c*, 15 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *406 b*, 22 May 1951 (as *Spirulina socialis* by Umezaki, 1952 a). *443 c*, 3 Aug. 1951 (as *Spirulina socialis* by Umezaki, 1952, 52 a).

Shima Peninsula: Wagu, *608 c*, 12 Mar. 1952 (as *Spirulina socialis* by Umezaki, 1955 a). *718 f*, 9 Jun. 1952 (as *Spirulina socialis* by Umezaki, 1955 a).

The specimens which have been referred to as *Spirulina socialis* in my papers (1952, 52 a, 55, 55 a) are placed here, because they bear close resemblance to *S. socialis* in the dimension and habit of the trichomes and the species was placed as a synonym of *S. tenerrima* by Drouet (1939, 42).

These plants have been found mostly as an epiphyte on the sheaths of Hydrocoleum, sometimes in company with *Lyngbya Rivulariarum*.

Geographical distribution: Cosmopolitan (in fresh water, rarely in brackish and marine waters).

2. **Spirulina major** Kuetzing, Phyc. Gener., p. 183, 1843; Phyc. Germ., p. 156, 1845; Gomont, Ann. Sci. Nat. VII. Bot. 16: 251, pl. 7, fig. 29, 1892; Umezaki, Journ. Jap. Bot. 30: 209, 1955.

Plants forming small blue-green masses; trichomes pale blue-green, 1μ in diameter, more or less flexuous, twisted in a regular and loose spiral with a diameter of 3μ; distance between coils 3μ. Pl. 10, fig. 8.

Habitat: Growing among or on the plants of larger algae (Ectocarpus and Gymnogongrus);

Shima Peninsula: Wagu, *764 b*, 9 Jun. 1952.

Wakasa Bay: Koiso, Maizuru Bay, *677*, 3 Jun. 1952.

A small amount of this alga, forming small blue-green masses among or on other algae, has been found at only two localities on our coasts.

This species is found in fresh and thermal waters of Japan (Osaka-shi 1933; Yoneda 1940, 52 a; Akatsuka 1951).

Geographical distribution: Cosmopolitan (in fresh, marine, or thermal waters).

3. **Spirulina subsalsa** Oersted seq. Gomont, Ann. Sci. Nat. VII. Bot. 16: 253, pl. 7, fig. 32, 1892; de Toni, Mem. R. Istit. Veneto 25: 65, 1895; Okamura, Synopt. List Jap. Alg. lst ed., p. 221, 1902; 1. c. 2nd ed., p. 266, 1916; Matsumura, Index Plant. Jap. 1: 3, 1904; Umezaki, Journ. Jap. Bot. 25: 226, fiig. 4, 1950; 1. c. 30: 209, 1955; Acta Phytotax. Geobot. 16: 87, 1956.

Plants often mixed with other algae, or forming bright blue-green, thin, membranaceous strata; trichomes 1–2μ in diameter, twisted in somewhat irregular or regular dense spirals with a diameter of 3–5μ; coils continuous to each other or almost so. Pl. 10, fig. 9.

Japanese name: Rasenmo (Umezaki 1950).

f. **subsalsa**

Trichomes 1.4–2μ in diameter, flexuous, twisted in somewhat irregularly coiled spirals.

f. **oceanica** (Crouan) Gomont, 1. c., 254, 1892.

Trichomes 1μ in diameter, nearly straight, twisted in regular, tightly coiled spirals.

Habitat: Growing among the plants of other algae (Lyngbya, Cladophora, Enteromorpha, Sphacelaria, Centroceras, and Sphacelaria), or in glass-vessels in which salt water had been placed for other algal culture.

Kii Peninsula: Seto, Shirahama, *388 a*, 22 May 1951.
Shima Peninsula: O-shima off Wagu, *618*, 12 Mar. 1952. Goza, *751 a*, 11 Jun. 1952.
Matsushima Bay: Shiogama, *1151 b*, 7 Jul. 1953.
Amino: Amino Bay, Kyoto Pref., *1105*, 23 Apr. 1953.
Wakasa Bay: Nagahama, Maizuru Bay, *27*, 16 Jun. 1949. *44*, 7 Sept. 1949.
Hokkaido: Oshoro, *1253 b*, 17 Jul. 1953. Hariusu near Otaru, *324 c*, 31 Aug. 1947.

Among the species of Spirulina, *S. subsalsa* is a most common species and is of a wide distribution in both fresh and marine waters, rarely in thermal waters. The present specimens have been found scattered among other algae, in many cases not forming a pure stratum. When living the trichomes make active but slow movement. I have observed this movement in the material which grew in a glass-vessel in my laboratory.

The species has been discovered in several hot springs in Japan (Emoto & Yoneda 1940 a, 41 a; and Yoneda 1938, 52 a, 54).

Geographical distribution: Cosmopolitan (in fresh, brackish, and marine waters, rarely in thermal waters).

4. **Spirulina labyrinthiformis** (Meneghini) Gomont, Ann. Sci. Nat. VII. Bot. 16: 255, 1892; Umezaki, Journ. Jap. Bot. 27: 117, fig. 17 A, 1952; l. c. 30: 209, 1955; Acta Phytotax. Geobot. 16: 88, 1956.

Plants solitary among other algae; trichomes short or long, pale blue-green, nearly straight, 1μ in diameter, twisted in regular and tight spirals with a diameter of 2–2.7μ. Pl. 10, fig. 10.

Japanese name: Hime-rasenmo (Umezaki 1955 a).

Habitat: Growing among the plants of filamentous algae (Hydrocoleum, Lyngbya, and Oscillatoria).

Seto Inland Sea: Tadano-umi, Hiroshima Pref., *302 c*, 8 Nov. 1950.
Shima Peninsula O-shima off Wagu, *819 c*, 5 Oct. 1952.
Mi-ura Peninsula: Jyoga-shima, *1041*, 30 Mar. 1953.
Wakasa Bay: Nagahama, Maizuru Bay, *1 b*, 4 Jul. 1949.
Hokkaido: Hariusu near Otaru, *324 d*, 13 Aug. 1947.

The plants in these collections are scanty; they do not form large plant masses as do other filamentous species. Generally the trichomes are short, especially as compared with those of *S. subsalsa* to which it seems to be closely related in its tightly and regularly coiled trichomes.

This species has been reported as occurring in hot springs of Japan by Yoneda (1939 c, 52 a).

Geographical distribution: In brackish or thermal waters. Atlantic coast of Europe (France); North Africa (Algeria); Pacific coast of North America (Mexico); Indian Ocean (India).

Genus 12. **Oscillatoria**

Vaucher, Histoire des Conferves d'eau douce, p. 165, 1803; Gomont, Journ. de Bot. 5: 273, 1891; Ann. Sci. Nat. VII. Bot. 16: 198, 1892.—Type species: *O. princeps* Vauch.

Plants solitary or forming layers; trichomes cylindrical, evaginate or rarely enclosed in very thin, fragile, mucous sheaths, often constricted at the cross walls, not moniliform, apices straight, curved, undulate, or more or less regularly twisted in spirals, often attenuate; apical cell often with calyptra.

Key to species of Oscillatoria:

1. Trichomes moderately thick; cells very short 2
1. Trichomes slender (not over 15μ); cells shorter or longer than the diameter, never very short 3
2. Trichomes 18.5–30μ in diameter ..... 1. *O. Bonnemaisonii*
2. Trichomes 14–18μ in diameter ..... 2. *O. margaritifera*
3. Trichomes twisted in loose spirals ..... 3. *O. chalybea*
3. Trichomes not twisted in spirals 4
4. Cells shorter than the diameter 5
4. Cells nearly quadrate or longer than the diameter 7

5. Trichomes 5-6.5μ in diameter..... 4. *O. brevis*
5. Trichomes 6-11μ in diameter..... 6
6. Trichomes moderately long, nearly straight..... 5. *O. nigro-viridis*
6. Trichomes very long, flexuous..... 6. *O. Corallinae*
7. Trichomes 6-8μ in diameter..... 7. *O. Yonedae*
7 Trichomes 1.5-4.5μ in diameter..... 8
8. Trichomes 4-4.5μ in diameter..... 8. *O. laetevirens*
8. Trichomes 1.5-2.5μ in diameter..... 9. *O. amphibia*

1. **Oscillatoria Bonnemaisonii** Crouan seq. Gomont, Ann. Sci. Nat. VII. Bot. 16: 215, pl. 6, figs. 17, 18, 1892; Akatsuka, Suisan Gakujyutsu-shiryo 1: 10, pl. 5, fig. 11, 1951; Umezaki, Journ. Jap. Bot. 29: 218, fig. 39 B, 1954; l. c. 30: 210, 1955; Publ. Seto Mar. Biol. Lab. 5: 421, 1956.

Plants intermixed with other algae; trichomes violet-green, elongate, very flexuous, twisted in loose or regular spirals, 18.5–30μ in diameter, apices very slightly attenuate or not; cross walls slightly constricted, not granulate; cells 3–6μ in length, 1/3–1/6 as short as the diameter; protoplasm finely or largely granular; apical cell convex, without a thickened outer-wall. Pl. 11, fig. 1.

Habitat: Growing intermixed with filamentous algae.

Amami Islands: Koniya, O-shima, *1806 e*, 11 Apr. 1955. Seisui near Koniya, O-shima, *2296*, 29 Jun. 1958.

Shima Peninsula: O-shima off Wagu, *822*, 5 Oct. 1952. Wagu, *800 b*, 4 Oct. 1952.

As Setchell & Gardner (1919) pointed out, the trichomes of a single collection do not show a great variation in diameter; although, according to Gomont (1892), they range from 18μ to 36μ in diameter. I have also noted in observation on Japanese specimens that those of a single collection do not show such a great variation: those from the Amami Islands are 20–30μ in diameter, and those from Shima Peninsula 18.5–22μ in diameter.

Geographical distribution: Subcosmopolitan (on rocks in marine water).

2. **Oscillatoria margaritifera** (Kuetzing) Gomont, Ann. Sci. Nat. VII. Bot. 16: 216, pl. 6, fig. 19, 1892; Akatsuka, Suisan Gakujyutsu-shiryo 1: 10, pl. 5, fig. 13, 1951.

Arthrospira breviarticulata Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 466, pl. 39, fig. 18 & pl. 41, fig. 26, 1918. *Spirulina breviarticulata* Geitler, Rabenh. Krypt. Fl. 14: 922, 1932.

Plants forming olive-green, gelatinous strata; trichomes yellowish-green, 14–18μ in diameter, apices slightly attenuate, straight; cross walls constricted, granulate; cells 3–6μ in length, 1/3–1/6 as short as the diameter; protoplasm large-granular; apical cell convex, with a slightly thickened calyptra. Pl. 11, fig. 2.

Habitat: Growing on corals in tide pools along high tide level.

Amami Islands: Kametsu, Tokuno-shima, *2477*, *2517*, 14 Jul. 1958.

The trichomes are very flexuous and sometimes twisted in spiral fashion, and

their dimension is a little slender than that of Gomont's description. The apical cell of the trichome is small and convex in shape and has a slightly thickened calyptra.

The type of *Arthrospira breviarticulata* Setch. & Gardn. preserved in the Herbarium, University of California at Berkeley, which was available for this study by the courtesy of Prof. G. Papenfuss, is very similar to these Japanese specimens and it is transferred here.

Geographical distribution: Cosmopolitan (in marine and brackish waters).

3. **Oscillatoria chalybea** Mertens seq. Gomont, Ann. Sci. Nat. VII. Bot. 16: 232, pl. 7, fig. 19, 1892; Yoneda, Acta Phytotax. Geobot. 9: 43, fig. 159, 1940; Umezaki, Journ. Jap. Bot. 27: 117, fig. 17 C, 1952; Publ. Seto Mar. Biol. Lab. 5: 421, 1956; Acta Phytotax. Geobot. 16: 88, 1956.

Plants scattered among other algae; trichomes pale blue-green or violet-green, twisted in loose spirals, 8–13μ or 15μ, mostly 12–13μ in diameter, apices gradually and slightly attenuate; cross walls slightly constricted, not granulate; cells nearly quadrate or 1/2–1/3 as short as the diameter, 3.5–5–(7.5)μ in length; apical cell obtuse, neither capitate nor calyptrate. Pl. 11, fig. 3.

Habitat: Growing among the plants of filamentous algae (Hydrocoleum, Polysiphonia, Sphacelaria, Cladophora, and Enteromorpha).

Amami Islands: Koniya, O-shima, *1758 c*, 9 Apr. 1955.

Shikoku: Usa, Kochi Pref., *1447 a*, 16 Jun. 1954.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1555 c*, 24 Jun. 1954. Shibukawa, Tamano, Okayama Pref., *1893 b*, 4 Aug. 1955.

Kii Peninsula: Hatake-jima, Tanabe Bay, *464 b*, 2 Aug. 1951.

Aomori Pref.: Asamushi near Aomori, *1192*, 9 Jul. 1953.

Hokkaido: Muroran, *1237*, 14 Jul. 1953. Oshoro, *1256*, 17 Jul. 1953. Lake Saroma, Kitami, *341 b*, K. Iwamoto, Aug. 1947.

Oscillatoria chalybea grows usually in fresh, thermal, or brackish waters, rarely in marine water. The trichomes from each station are scarce, not forming large masses, but scattered among other filamentous algae. The Japanese specimens, the trichomes of which have diameters of 8–15μ, mostly 12–13μ and are loosely twisted in spirals, belong to the var. *anguina*.

The species was reported by Yoneda in 1940, as occurring on a pier at Beppu, Oita Prefecture, Kyushu.

Geographical distribution: Cosmopolitan (in fresh, thermal, brackish waters, rarely in marine water).

4. **Oscillatoria brevis** Kuetzing, Phyc. Gener., p. 186, 1843; Phyc. Germ., p. 159, 1845; Spec. Algar., p. 240, 1849; Tab. Phyc., I, p. 28, pl. 39, fig. 6; Gomont, Ann. Sci. Nat. VII. Bot. 16: 229, pl. 7, figs. 14, 15, 1892; Akatsuka, Suisan Gakujyutsu-shiryo 1: 10, pl. 5, fig. 14, 1951.

Plants intermixed with other algae; trichomes comparatively short, nearly straight, blue-green, 5–6.5 μ in diameter, apices briefly or somewhat gradually attenuate, curved and hooked; cross walls not constricted, not granulate; cells 2–3 μ in length; protoplasm finely granular; apical cell without a calyptra. Pl. 11, fig. 8.

Habitat: Growing intermixed with Cladophora and other Cyanophyta in rock depressions in the littoral belt.

Aomori Prefecture: Asamushi near Aomori, *1193 b*, 9 Jul. 1953.

Setchell and Gardner (1919) pointed out a mistake between Gomont's diagnosis and his figure (1. c.) of this species concerning the granules on the cross walls of the trichome. Frémy (1934) described to be not granulated on the cross walls and figured a trichome without granules in his figure. In the Japanese specimens the cross walls are not granulated. As Setchell and Gardner pointed out I also think Gomon't figure must have mistaken.

The Japanese specimens belong to the var. *neapolitana*; the trichomes are 5–6.5 μ in diameter and their apices are curved and hooked.

This species was reported as occurring in fresh water and many hot springs of Japan by Emoto and Hirose (1941), Emoto and Yoneda (1940, 40 a, 41 a, 42) and Yoneda (1937, 39 c, 42 b, 52 a).

Geographical distribution: Cosmopolitan (on rocks in fresh, brackish, or marine waters).

5. **Oscillatoria nigro-viridis** Thwaites in Harvey, Phyc. Brit., Synopsis 3: 39, pl. 251 A, 1849; Gomont, Ann. Sci. Nat. VII. Bot. 16: 217, pl. 6, fig. 20, 1892; Umezaki, Journ. Jap. Bot. 26: 267, fig. 13 A, 1951; 1. c. 30: 209, 1955; Publ. Seto Mar. Biol. Lab. 5: 421, 1956.

Plants blackish-violet, thin-membranaceous; trichomes olive-green, moderately long, nearly straight, fragile, 7–11 μ in diameter, apices curved and slightly attenuate; cross walls constricted, granulate; cells 3–5 μ in length, 1/2–1/4 as short as the diameter; apical cell subcapitate, with a convex and slightly thickened outer-wall. Pl. 11, fig. 5.

Japanese name: Kuro-yuremo (Umezaki 1951).

Habitat: Growing on rocks, concrete or other algal masses in the supralittoral or upper littoral belt.

Amami Islands: Asani near Naze, O-shima, *1704*, *1708*, 6 Apr. 1955. Naze, O-shima, *1845*, *1847*, *1848*, *1872*, 12 Apr. 1955. *2176*, *2179*, 24 Jun. 1958. Gusuku, Sumiyo-mura, O-shima, *1716*, 7 Apr. 1955. Yamma, Sumiyo-mura, O-shima, *1737*, 8 Apr. 1955. Seisui near Koniya, O-shima, *2308*, 29 Jun. 1958. Ikeji, Kikai-jima, *2350*, *2376*, 6 Jul. 1958. Wan, Kikai-jima, *2424*, 7 Jul. 1958. Kametsu, Tokuno-shima, *2527*, 15 Jul. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2029 c*, *2030 b*, *2031 a*, *2036 b*, *2043*, *2051 b*, *2053 a*, 25 May 1956. Ao-shima, Miyazaki Pref., *2078*, *2086*, 27 May 1956.

Shikoku: Katsurahama, Kochi, *1405*, *1406 a*, *1408*, *1426 b*, *1434*, *1442 a*, 15–16 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1909 a*, 5 Aug. 1955. Hon-jima,

Shiaku Islands, *1931 c*, *1933 c*, 5 Aug. 1955.

Shimonoseki: Yoshimi, *264*, 5 Nov. 1950.

Kii Peninsula: Hatake-jima, Tanabe Bay, *473 a*, 2 Aug. 1951. Seto, Shirahama, *522 b*, 1 Nov. 1951. Yuzaki, Shirahama, *647*, *648*, *649*, 30 Mar. 1952.

Shima Peninsula: O-shima off Wagu, *811*, *813 a*, *819 b*, 5 Oct. 1952. Wagu, *697*, *702 b*, 9 Jun. 1952. Akogi-ura, Tsu, *684 a*, 7 Jun. 1952.

Izu Peninsula: Shimoda, *854*, *860*, *868 b*, *872*, 9 Oct. 1952.

Mi-ura Peninsula: Jyoga-shima, *1018*, 30 Mar. 1953.

Boso Peninsula: Kominato, *1074*, 3 Apr. 1953.

Matsushima Bay: Yogasaki, *1147 b*, 7 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *1275*, 31 Aug. 1953.

Wakasa Bay: Nagahama, Maizuru Bay, *1 a*, 4 Jul. 1949. *21 b*, 16 Jun. 1949. *23*, 24 May 1949. Kanmuri-jima off Maizuru Bay, *660*, 18 May 1952. Kanagasaki, Tsuruga Bay, *201*, 4 Aug. 1952.

Oscillatoria nigro-viridis is a truly marine and widespread species. It is a common species on our coasts, although from two stations in the northern areas, Hokkaido and Aomori Prefecture, it has not been detected. The plant, as the specific name indicates, is coloured blackish-violet and is thin-membranaceous, sometimes abundantly covering rocks; it is easy to discover when one is wading on rocky shores. The plants, in many cases, have been found in pure growths, whereas many filamentous and coccoid species of Cyanophyceae have been found mostly intermixed with other species or associated with one another. Granules are found along the cross walls of the trichome; but sometimes there disappear, even in the living plants.

From Japanese hot springs and fresh water it was discovered by Emoto and Yoneda (1940 a), Osaka-shi (1933), and Yoneda (1940, 52 a).

Geographical distribution: Cosmopolitan (on logs, mud, concrete, or rocks in marine water).

6. **Oscillatoria Corallinae** (Kuetzing) Gomont, Journ. de Bot. 4: 356, 1890; Ann. Sci. Nat. VII. Bot. 16: 218, pl. 6, fig. 21, 1892; Umezaki, Journ. Jap. Bot. 26: 268, fig. 13 c, 1951; l. c. 30: 209, 1955; Acta Phytotax. Geobot. 16: 88, 1956.

Spirulina attenuata Umezaki, Journ. Jap. Bot. 27: 117, fig. 17 B, 1952; l. c. 30: 209, 1955; Bot. Mag. Tokyo 68: 66, 1955.

Plants intermixed with other algae, or densely gregarious, blue-green; trichomes very long, flexuous, 6–10 μ in diameter, apices gradually curved and very slightly attenuate; cross walls constricted, not granulate; cells 2.7–4 μ in length, 1/2–1/3 as short as the diameter; protoplasm sometimes granular; apical cell subcapitate, with a slightly thickened, convex outer-wall. Pl. 11, fig. 6.

Habitat: Growing on or among the plant masses of larger algae (Cladophora, Sargassum, Lyngbya, and Calothrix), or rarely on rocks.

Tokara Islands: Takara-jima, *1139 m*, E. Ogata, 27 May 1953 (as *Spirulina attenuata* by Umezaki, 1955).

Kyushu: Cape Kaimon, Kagoshima Pref., *2105*, 26 May 1956. Tomioka, Amakusa, *2003 b*, 22 May 1956.

Shimonoseki : Yoshimi, on rocks in the upper littoral belt, associated with *Calothrix crustacea*, *262 b*, 5 Nov. 1955 (Type of *Spirulina attenuata*).

Shikoku : Usa, Kochi Pref., *1409*, 15 Jun. 1954.

Seto Island Sea : Ozuchi-jima off Tamano, Okayama Pref., *1687*, 9 Feb. 1955.

Shima Peninsula : O-shima off Wagu, *620*, 12 Mar. 1952. *737 d*, 10 Jun. 1952 (as *Spirulina attenuata* by Umezaki, 1955 a). *825*, 5 Oct. 1952. Goza, *598 b*, 11 Mar. 1952. Wagu, *612*, 12 Mar. 1952. *705 b*, *717*, 9 Jun. 1952 (as *Spirulina attenuata* by Umezaki, 1955 a).

Wakasa Bay : Sanbonmatsuhana, Maizuru Bay, *1961 c*, 7 Nov. 1955. Suizu, Tsuruga Bay, *210 b*, *211*, 5 Aug. 1950.

Hokkaido : Muroran, *323 c*, 31 Aug. 1947. *325 c*, 22 Jul. 1947. *1217 a*, 14 Jul. 1955. Oshoro, *1253 e*, 17 Jul. 1953.

The habit of this species is usually epiphytic on other algae, but more frequently it has been found intermixed with other filamentous algae in the specimens at hand. This species is closely related to *O. nigro-viridis* except for the more flexuous and larger trichomes. *Spirulina attenuata* Umezaki (1952) is placed here ; probably it is a young plant of *O. Corallinae*.

Geographical distribution : Cosmopolitan (on algae in marine water).

7. **Oscillatoria Yonedae** Umezaki, sp. nov.

Planta inter alias algas solitaria vel gregaria ; trichomata aubflavo-viridis, elongata, recta vel subflexuosa, 6–8 μ crassa, ad genicula non aut vix constricta, haud granulata, ad apices recta, haud attenuata ; cellulis 6–12 μ longis, quadratis vel diametro duplo longioribus, protoplasmate tenui granuloso ; cellula apicali rotundata ; calyptra nulla. (v.v.v.). Pl. 11, fig. 4.

Habitat : Growing on the plants of Callithamnion.

Amami Islands : Kametsu, Tokuno-shima, *2526*, 15 Jul. 1958 (Type).

The plants grow loosely intricated among the branches of a Callithamnion. The trichomes with straight terminal portions are very long, nearly straight or slightly flexuous, never twisting in spirals as in *O. chalybea*.

This species, a member of Gomont's Aequales, is near *O. simplissima* Gom., which grows usually in fresh or warm waters. It differs most remarkably from the latter species in its more longer cells, usually longer than the diameter. It is named in honour of Dr. Yoneda.

8. **Oscillatoria laetevirens** Crouan, Bull. Soc. Bot. de Fr. 7 : 371, 1860 ; Gomont, Ann. Sci. Nat. VII. Bot. 16 : 226, pl. 7, fig. 11, 1892 ; Umezaki, Journ. Jap. Bot. 26 : 267, fig. 13 B, 1951 ; l. c. 30 : 209, 1955 ; Publ. Seto Mar. Biol. Lab. 2 : 244, 1952 ; Acta Phytotax. Geobot. 16 : 88, 1956.

Plants thin-membranaceous, dirty-green or bright green ; trichomes pale blue-green, or yellowish-green, long or short, straight, 4–4.5 μ in diameter, apices briefly or gradually attenuate, slightly curved or straight ; cross walls slightly constricted, with a few granules ; cells 2.5–5 μ in length, nearly quadrate or half as short as the diameter ; protoplasm uniformly granular ; apical cell obtuse- or subacute-conical, neither

capitate nor calyptrate. Pl. 11, fig. 7.

Habitat: Growing on rocks, concrete or wood in the upper or lower littoral belt, or among the filaments of Cladophora, usually associated with other species of Cyanophyta.

Shikoku: Katsurahama, Kochi, *1406 b*, 17 Jun. 1954.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1893 a*, *1895 a*, 4 Aug. 1955. Tadanoumi, Hiroshima Pref., *301 c*, 8 Nov. 1950.

Kii Peninsula: Seto, Shirahama, *408 d*, 22 May 1951.

Shima Peninsula: Goza, *751 b*, 11 Jun. 1952.

Matsushima Bay: Yogasaki, *1147 a*, 7 Jul. 1953.

Wakasa Bay: Nagahama, Maizuru Bay, *21 b*, 16 Jun. 1949. *45*, 7 Sept. 1949.

Hokkaido: Oshoro, *1253 d*, 17 Jul. 1953.

The Japanese specimens have been found mostly associated with other Cyanophycean algae, rarely forming pure strata. The cross walls of the trichome are sometimes not granulated, and the apex of the trichome is sometimes gradually attenuated as in *O. subuliformis*, to which it is closely related. From *O. brevis*, which it also resembles, it differs in its nearly straight trichomes, its longer cells, and its constricted cross walls.

Geographical distribution: On rocks, mud, or mollusks in marine water or in inland salt waters. Atlantic coast of Europe (Sweden, Baltic Sea, France, British Isles); Atlantic coast of North America (Nova Scotia); Pacific coast of North America (Washington, California, Mexico); West Indies (Barbados, Puerto Rico); Pacific Ocean (Hawaiian Islands, Palmyra Island, New Zealand); Southeast Asia (Philippines); Indian Ocean (Ceylon).

9. **Oscillatoria amphibia** C. Agardh, Flora 10: 632, 1827; Gomont, Ann. Sci. Nat. VII. Bot. 16: 221, pl. 7, figs. 4, 5, 1892; Yoneda, Acta Phytotax. Geobot. 7: 164, fig. 103, 1938.

Plants mixed with other algae; trichomes nearly straight or contorted, fragile, 1.5–2.5μ in diameter, apices not attenuate; cross walls not constricted, with granules, generally indistinct; protoplasm homogeneous; cells 2–3 times as long as the diameter, 3–6μ in length; apical cell round, without calyptra. Pl. 11, fig. 9.

Habitat: Growing intermixed with other species in rock depressions in the supralittoral belt.

Hokkaido: Oshoro, *1253 c*, 17 Jul. 1953 (as *Oscillatoria limnetica* by Umezaki, 1956 a).

The specimen from Hokkaido, which was referred to *Oscillatoria limnetica* by me (1956 a) is removed to *O. amphibia*, which it is rather near. The cross walls of the trichome are generally obscure, although distinct here and there, especially in the apical portion; so that it is impossible to measure exactly the cell length.

The species has been reported from hot springs in Japan by several phycologists (Emoto & Hirose 1939, 41; Emoto & Yoneda 1940, 40 a, 41 a, 42; Molisch 1926; and Yoneda 1938, 38 a, 39 b, c, 41 a, b, 42 a, 52 a).

Geographical distribution: Cosmopolitan (in fresh, brackish, and thermal waters, terrestrial, and rarely in marine water).

Genus 13. **Skujaella**

J. de Toni, Diagn. Alg. Nov., I, 4, no. 397, 1938; Archivio Bot. 15: 291, 1939.

Trichodesmium Ehrenberg seq. Gomont, Ann. Sci. Nat. VII. Bot. 16: 193, 1892.—Type species: *T. erythraeum* Ehrenb.

Plants free-floating, aggregate in scale-like bundles; trichomes cylindrical, evaginate, apices straight, attenuate; apical cell capitate, truncate-conical, with convex calyptra.

Key to species of Skujaella:

1. Trichomes 10-20μ in diameter; cells nearly quadrate or 1/2-1/3 as short as the diameter..... ..... 1. *S. Hildebrandtii*
1. Trichomes 6-8μ in diameter; cells nearly quadrate or up to 2 times as long as the diameter... ..... 2. *S. Thiebautii*

1. **Skujaella Hildebrandtii** (Gomont) J. de Toni, Archivio Bot. 15: 292, 1939.

Trichodesmium Hildebrandtii Gomont, Ann. Sci. Nat. VII. Bot. 16: 197, pl. 6, fig. 1, 1892. *Oscillatoria Hildebrandtii* Geitler, Rabenh. Krypt. Fl. 14: 968, 1932.

Plants free-floating fascicles, 1–2 mm. in length, pale violet; trichomes straight, 10–20μ in diameter, apices slightly attenuate or not; cross walls not constricted; cells 3–8μ in length, nearly quadrate or 1/2–1/3 as short as the diameter; protoplasm homogeneous or finely granular, or aggregate at the center; apical cell round, with calyptra. Pl. 11, fig. 10.

Habitat: Growing planktonic in the sea.

Kyushu: Goto and Danjyo Islands, *2127*, T. Tsujita, July 1955. Tsuyasaki, Fukuoka Pref., *2655*, T. Sawada, 26 Aug. 1959.

Kii Peninsula: Tanabe Bay, *2130*, I. Yamaji, summers of 1955 and 1956.

Boso Peninsula: Nojimazaki, *2673*, H. Takano.

I have received some specimens preserved in formalin solution from Dr. T. Tsujita, who collected them in the sea between Goto and Danjyo Islands off Nagasaki, Kyushu, where their rapid and abundant growth prompted him (1956) to call it an explosive multiplication by which the water was coloured white. The bundles of trichomes are pale violet; when settled on the bottom of the glass bottle, they are deep violet. The trichomes are short, nearly straight or slightly curved, of the same diameter throughout the entire length or rarely slightly attenuated at the apices. The protoplasm, in material preserved in formalin solution, is aggregated at the center of the cell in many cases and the outer part becomes transparent; so that the individual trichome is colourless under the microscope. Perhaps for this reason when the plants explosively multiply, the water is coloured white instead of red or violet.

Mr. T. Sawada gave me some specimens of this species preserved in formalin solution and wrote me that the planktonts were found producing dense red waters 20–30 cm. thick in the surface water off the Tsuyasaki coast and that the waters were grayish-green in colour and gave out an offensive smell when they were collected. The present materials preserved in formalin solution are changed gray in colour.

For the Japanese marine flora, this species, as *Trichodesmium Hildebrandtii*, was for the first time recorded by K. Akatsuka (1951).

Geographical distribution: Planktonic in the tropical ocean. Indian Ocean (Ceylon, Madagascar); Southeast Asia (Siam, Malaya, Indonesia); Atlantic coast of North America (Florida).

2. **Skujaella Thiebautii** (Gomont) J. de Toni, Archivio Bot. 15: 292, 1939.

Trichodesmium Thiebautii Gomont, Ann. Sci. Nat. VII. Bot. 16: 197, pl. 6, figs. 2-4, 1892; Okamura, Annot. Zool. Jap. 6: 126, fig. 46, 1907; Synopt. List Jap. Alg. 2nd ed., p. 266, 1916; Kokubo, Fuyu-Seibutsu Bunruigaku, 1st ed., p. 286, pl. 34, fig. 3, 1932; l. c. 2nd ed., p. 431, pl. 34, fig. 3, 1955; Akatsuka, Suisan Gakujyutsu-shiryo 1: 11, pl. 6, fig. 11, 1951. *Oscillatoria Thiebautii* Geitler, Rabenh. Krypt. Fl. 14: 967, fig. 617 c, d, 1932.

Plants free-floating fascicles, up to 2 mm. in size, pale violet; trichomes forming fascicles loosely aggregated, always curved, 6–8μ in diameter, apices slightly attenuate or not; cross walls not constricted; cells 8–15μ in length, nearly quadrate or up to 2 times as long as the diameter; protoplasm largely granular. Pl. 11, fig. 11.

Habitat: Planktonic in the sea.

Kyushu: Tsuyasaki, Fukuoka Pref., *2576*, T. Sawada, 9 Jan. 1959.

Mr. Sawada, who sent me this specimen, said in his letter that the plankton alga was abundantly found producing red waters in shore at Tsuyasaki. Moreover, he said that the red tide must have occurred in the open sea off this coast and reached to this shore, probably due to the strong wind blown on the 9th of January when the plankton was collected.

The Japanese plant of this species was collected during the cold season of the year, although the species is generally distributed in tropical or subtropical warmer waters. Some of the present plants are loosely agglutinated in fascicles as in the typical form and some are found as individual trichomns, not forming fascicles. Most of the trichomes are curved, but their apices are straight. No inflated apical cell of the trichome has been found in this material.

The present species (as *Trichodesmium Thiebautii*) for the Japanese marine flora was recorded by Okamura (1907, 16), Kokubo (1932, 55), and Akatsuka (1951).

Geographical distribution: Planktonic in the tropical or subtropical oceans. Atlantic Ocean (Canary Islands, Bermuda); Mediterranean (France, Italy); West Indies (Bahamas, Guadeloupe); Atlantic coast of North America (Florida); South America (Brazil); Pacific Ocean (Hawaiian Islands); Southeast Asia (Indonesia, Malaya).

Suborder 2. **Nostochineae**

Smith, Fresh-water Alg. of United States, 2nd ed., p. 580, 1950.

Trichomes uniseriate or multiseriate, of the same diameter throughout or attenuate either from the base to the apex or from the middle to both ends, straight or flexible, unbranched or branched; branching true or false; sheaths usually present, enclosing one or many trichomes, hyaline or coloured, homogeneous or lamellate, firm or gelatinous; heterocysts present except in some species; reproduction by hormogones or by spores.

Key to families:

1. Trichomes unbranched ..... 1. *Nostocaceae*
1. Trichomes usually branched 2
2. Branching usually true, rarely false ..... 2. *Stigonemataceae*
2. Branching false 3
3. Trichomes of the same diameter throughout or slightly attenuate at the apices ..... 3. *Scytonemataceae*
3. Trichomes attenuate from the base to the apex or from the middle to both ends. ..... 4. *Rivulariaceae*

Family 1. **Nostocaceae**

Kuetzing, Phyc. Gener., p. 203, 1843; Thuret, Ann. Sci. Nat. VI. Bot. 1: 6, 1875; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 7: 177, 1888.—Type genus: *Nostoc* Vauch.

Plants macroscopic, gelatinous, cushion-shaped, spherical, or forming a stratum, or microscopic and flake-shaped or filamentous; sheaths present or rarely not present, soft, gelatinous, often entirely diffluent, or rarely firm; trichomes unbranched, uniseriate, not differentiated into a base and an apex, never attenuate into a hair, both ends usually similar; heterocysts intercalary or terminal; reproduction by hormogones and spores; growth intercalary.

Key to genera:

1. Plants growing within diatoms; sheaths not present; heterocysts terminal ..... 1. *Richelia*
1. Plants not growing within diatoms; sheaths present; heterocysts intercalary 2
2. Plants thick-membranaceous; filaments intricate, flexible ..... 2. *Nostoc*
2. Plants consisting of single filaments or soft fascicles of filaments 3
3. Filaments free ..... 3. *Nodularia*
3. Filaments parallel, aggregated in soft fascicles ..... 4. *Hormothamnion*

Genus 1. **Richelia**

J. Schmidt, Hedwigia 40: 113, 1901.—Type species: *R. intracellularis* J. Schmidt.

Plants endophytic within diatom-cells; trichomes evaginate, single, paucicellular, short; heterocysts solitary, terminal.

One species:

Richelia intracellularis J. Schmidt, Hedwigia 40: 113, fig. 1, 1901; Okamura, Kaisogaku Hanron, supp., p. 5, fig. 33, 1902; Synopt. List Jap. Alg. 2nd ed., p. 266, 1916; Akatsuka, Suisan Gakujyutsu-shiryo 1: 17, pl. 10, fig. 1, 1951; Umezaki, Journ. Jap. Bot. 28: 239, fig. 33, 1953.

Plants endophytic within the cells of diatom; trichomes straight or nearly straight, thickened at the apex, short, 33–55μ in length, 6–8.5μ in diameter; cells nearly spherical or half as short as the diameter; apical cell often a little larger than others, nearly spherical; protoplasm finely granular, pale blue-green; heterocysts larger than the other cells, 8.5–12μ in diameter, spherical or nearly spherical. Pl. 12, fig. 1.

Habitat: Growing in the cells of *Rhizosolenia styliformis*.

Amino: Amino Bay, Kyoto Pref., *925*, 28 Oct. 1952.

Wakasa Bay: Maizuru Bay, *1637a*, 29 Aug. 1954.

Okamura (1902 a) introduced for the first time this species in his book "Kaisogaku Hanron (in Japanese)," quoted from J. Schmidt's description and figure (1901); and he (1916) listed it in his "Synoptic List of the Japanese Algae," as occurring off Bosyu and at other localities. Akatsuka (1951) also reported its occurrence in the Japanese water.

The present species has been found at only two localities along the Japan Sea coast in this study; but if more explorations are made, it will probably be discovered at other localities also.

Geographical distribution: Endophytic in marine diatoms (Rhizosolenia, Chaetoceras, Hemiaulus). Atlantic coast of Europe (France); Pacific Ocean (Hawaiian Islands); South America (Brazil); Indian Ocean (India).

Genus 2. **Nostoc**

Vaucher, Hist. Conferv. d'eau douce, p. 203, 1803; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 7: 181, 1888.—Type species: *N. commune* Vauch.

Plants mucous, gelatinous, or coriaceous, usually globose or oblong when young, later becoming globose, foliose, filiform, or bulbous according to the species, solid or cavernous, floating or attached, usually with more or less firm periderm; filaments flexible, curved, entangled; sheaths sometimes distinct, sometimes confluent and visible; trichomes torulose; cells depressed-spherical, barrel-shaped, or cylindrical; heterocysts intercalary and (when young) terminal; reproduction by spores; spores spherical or oblong, seriate, beginning midway between heterocysts and developing centrifugally.

One species:

Nostoc commune Vaucher, Hist. Conferv. d'eau douce, p. 222, tab. 16, fig. 1, 1803; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 7: 203, 1888; Okamura, Synopt.

List Jap. Alg. 1st ed., p. 200, 1902; Matsumura, Index Plant. Jap. 1: 3, 1904; Umezaki, Bot. Mag. Tokyo 68: 66, 1955.

Plant yellowish-green, somewhat gelatinous, thick-membranaceous, 3.5 cm. in diameter; filaments flexible, entangled; sheaths brownish near the surface of plant, in the interior hyaline, indistinct; trichomes 5–6μ in diameter; cells depressed-spherical or barrel-shaped, 4–6.2μ in length; heterocysts ovoid, solitary, never seriate, 6.3–7.7μ in diameter, 7–9μ in length; spores unknown. Pl. 12, fig. 2.

Habitat: Growing on rocks.

Tokara Islands: Takara-jima, *1139 a*, E. Ogata, 27 May 1953.

Only this one specimen has been collected on the Japanese coast, although the species has been found at various localities in Japan in terrestrial habitats (Hirose 1938; Okamura 1902; and Yoneda 1938, 50, 53).

The intercalary heterocysts are usually single at each position instead of being two or more in a series; although according to Bornet & Flahault and most of other phycologists, they are described as being formed up to three or five in series. Since the Japanese plant is young, spores are not present.

Geographical distribution: Cosmopolitan (on rocks in fresh water or rarely in marine water, or terrestrial).

Genus 3. **Nodularia**

Mertens seq. Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 7: 243, 1888.—Type species: *N. spumigena* Mertens.

Plant a single filament or a mucous mass; filaments free, simple, straight or curved; sheaths hyaline, usually delicate, mucous, sometimes diffluent; trichomes single within a sheath; cells short, depressed-disc-shaped; heterocysts intercalary or terminal, depressed, longer or usually a little shorter than the vegetative cells; reproduction by spores; spores globose, subglobose or disc-shaped, developing in a series between the heterocysts; walls of spores smooth.

One species:

Nodularia Harveyana (Thwaites) Thuret, Ann. Sci. Nat. VI. Bot. 1: 378, 1875; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 7: 243, 1888.

Plants solitary or entangled; filaments straight or slightly curved, 6–9μ in diameter; sheaths thin, hyaline, sometimes diffluent; cells 4.5–6μ in diameter, 3–5μ in length, nearly spherical or shorter than the diameter; protoplasm blue-green, homogeneous; spores unknown. Pl. 12, fig. 3.

Habitat: Growing among the plants of filamentous algae (Ectocarpus, Cladophora, young Enteromorpha, Lyngbya, and Hydrocoleum) in the upper or supralittoral belt.

Shikoku: Usa, Kochi Pref., *1418 a*, *1419 a*, *1421 b*, 15 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *388 d*, 22 May 1951.

Shima Peninsula: Wagu, *698 a*, 9 Jun. 1952.

Wakasa Bay: Cape Bakuchi, Maizuru Bay, *1890 b*, 6 Jul. 1955.

Nodularia Harveyana has been found at several stations on the Japanese coast, but the plants in each collection are few. The sheaths, which are usually thin and hyaline, are sometimes diffluent. Spores have not been found in any of the specimens at hand, so that reproduction of these Japanese algae may be due to the fragmentation of the trichomes, or the alga may be young.

Geographical distribution: Subcosmopolitan (in fresh and marine waters, sometimes in thermal water or in dripping sap of trees).

Genus 4. **Hormothamnion**

Grunow, Novara Exp. Bot. Theil. 1: 31, 1867; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 7: 259, 1888.—Type species: *H. enteromorphoides* Grun.

Plant a caespitose layer in which the filaments are aggregated in a parallel manner, sometimes an expanded, erect, filiform, branched fascicle; sheaths enclosing single trichomes, thin, hyaline, often mucous, obscure, or diffluent; trichomes moniliform; heterocysts intercalary; spores unknown.

One species:

Hormothamnion enteromorphoides Grunow, Novara Exp. Bot. Theil. 1: 31, tab. 1, fig. 2, 1867; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 7: 260, 1888; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 420, fig. 5, 1956.

Plants bright blue-green, gelatinous, turf-like, composed of simple, erect, soft fascicles like those of *Symploca hydnoides*; filaments nearly parallel or irregularly branched, closely associated, 9–11μ in diameter; sheaths hyaline, delicate or sometimes becoming thick with age; trichomes blue-green, 8–9μ in diameter, sometimes slightly attenuate towards the ends, constricted at the cross walls; cells nearly spherical or a little shorter than the diameter, 4.5–7.5μ in length; apical cell blunt-conical; heterocysts quadrate or rectangular, 9–10.5μ in diameter, 10–15.5μ in length; spores unknown. Pl. 12, fig. 4.

Japanese name: Tadare-nori (nom. nov.).

Habitat: Growing on rocks or larger algae (Hypnea, Laurencia, Padina, Sargassum, and Boodlea) in the lower littoral or infralittoral belt, or free-floating.

Amami Islands: Koniya, O-shima, *1757*, *1772*, *1824 a*, *1826*, 9-11 Apr. 1955. Tean near Koniya, O-shima, *2183*, *2184*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2213*, *2288*, *2292*, *2306*, 29 Jun. 1958. Urasokari near Koniya, *2346*, *2539*, 1 Jul. 1958. Naze, O-shima, *2203*, 24 Jun. 1958. Sakihara, Kasari-mura, O-shima, *2450*, *2458*, *2465*, 11 Jul. 1958. Kasari, O-shima, *2281*, Y. Yoneda, 11 Jul. 1958. Shiba, Kakeroma-to, *2215*, Y. Yoneda, 29 Jun. 1958. Ankyaba, Kakeroma-to, *2314*, 30 Jun. 1958. Kametsu, Tokuno-shima, *2483*, *2490*, *2502*, 14-15 Jul. 1958.

Tokara Islands: Takara-jima, *1139 h*, E. Ogata, 27 May 1953 (as *Anabaena* sp. by Umezaki, 1955).

Hormothamnion enteromorphoides is not uncommon in the warmer seas, especially in the tropical or subtropical regions where it probably originated. On the Japanese coast it has been found on the subtropical Amami and Tokara Islands, in the southernmost waters of Japan, which are included in the Southwestern Islands Region in this paper.

The plant, which is coloured bright blue-green and formed of gelatinous soft fascicles, has been found growing on rocks or on other larger algae (Hypnea, Padina, Laurencia, and Sargassum), or floating free. The sheath is thin, hyaline, sometimes entirely diffluent. Spores, which are of great importance in the specific classification of the Nostocaceae, have never been discovered in species of Hormothamnion. Likewise, in the present specimens, no spores have been found in spite of careful observations of abundant material.

Geographical distribution: On algae in marine water. Atlantic coast of North America (Florida); Pacific coast of North America (Mexico); Atlantic Ocean (Canary Islands); West Indies (Guadeloupe, Puerto Rico, Jamaica, Barbados); Pacific Ocean (Tongataba Island, Marshall Islands); Southeast Asia (Indonesia); Indian Ocean (India).

Family 2. **Stigonemataceae**

Kirchner in Engler & Prantl, Natuerl. Pflanzenfam. I, 1 a, p. 80, 1898; Setchell & Gardner, Univ. Calif. Publ. Bot. 8: 109, 1919; Drouet, Cyanophyta in Smith's Man. of Phyc., p. 162, 1951.—Type genus: *Stigonema* Ag.

Plants filamentous, forming gelatinous cushions or layers; filaments branched mostly truly or rarely falsely; sheaths firm or gelatinous, hyaline or coloured, homogeneous or lamellate; trichome cylindrical or torulose, the cells uniseriate or multiseriate; cells depressed-spherical, cylindrical, or irregularly angular; heterocysts intercalary, lateral or terminal; reproduction by hormogones, or rarely by spores.

Key to genera:

1. Plants perforating mollusk shells; heterocysts lateral or terminal..... 1. *Mastigocoleus*
1. Plants not perforating mollusk shells; heterocysts intercalary..... 2
2. Plants cavernous, cartilaginous, or microscopic; branches scytonematoid, Y-shaped, or branched without loop-formation; sheaths mostly diffluent..... 2. *Brachytrichia*
2. Plants flat-crustaceous, firm; branches V-shaped; sheaths firm..... 3. *Kyrtuthrix*

Genus 1. **Mastigocoleus**

Lagerheim, Notarisia 1: 65, 1886; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 5: 54, 1887.—Type species: *M. testarum* Lagerh.

Plants perforating mollusk shells, filamentous, intricate; filaments free, irregularly branched; trichomes of the branches uniseriate; branches cylindrical or flagelliform (attenuating into hairs); sheaths continuous, firm; heterocysts solitary, rarely two together, terminal or lateral, never intercalary; protoplasm homogeneous; reproduc-

tion by hormogones; spores unknown.

One species:

Mastigocoleus testarum Lagerheim, Notarisia 1: 65, tab. 1, 1886; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 5: 54, 1887; Umezaki, Journ. Jap. Bot. 28: 203, fig. 30 A, 1953; l. c. 30: 62, 1955; Acta Phytotax. Geobot. 16: 87, 1956; Publ. Seto Mar. Biol. Lab. 5: 418, 1956.

Plants perforating mollusk shells or corals, pale blue-green; filaments variously intricate, 6–7.5μ in diameter; sheaths hyaline, delicate, firm; trichomes 3.5–6μ in diameter, sometimes ending in slender, hyaline hairs; cells 4–12.5μ in length, a little shorter than the diameter or up to 2.5 times as long as the diameter; protoplasm pale blue-green or yellowish-green, sometimes large-granular; heterocysts terminal and lateral, spherical or ellipsoidal, 5–13μ in diameter. Pl. 12, fig. 5.

Japanese name: Kaitsuki-aimo (Umezaki 1955 a).

Habitat: Growing in mollusk shells or in corals, or rarely in the plants of Galaxaura.

Amami Islands: Asani near Naze, O-shima, *1712 a*, 6 Apr. 1955. Ushuku, Kasari-mura, O-shima, *1876 a*, 13 Apr. 1955. *2444*, 10 Jul. 1958. Kasari, O-shima, *2257*, *2275*, Y. Yoneda, 10 Jul. 1958. Koniya, O-shima, *1782 c*, *1839 a*, 11 Apr. 1955. Tean near Koniya, O-shima, *2283*, 28 Jun. 1958. Ankyaba, Kakeroma-to, *2498*, 30 Jun. 1958.

Kyushu: Tomioka, Amakusa, *2006 a*, *2012 a*, *2095 a*, 23 May 1956.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1496 a*, *1498 a*, 22 Jun. 1954. *1898 b*, 4 Aug. 1955. Ozuchi-jima off Tamano, Okayama Pref., *1600*, 29 Sept. 1954. *1693*, 10 Feb. 1955. *1914 b*, 5 Aug. 1955. Hon-jima, Shiaku Islands, *1543 c*, 23 Jun. 1954. *1603 c*, *1623*, 29–30 Sept. 1954. *1955 a*, 5 Aug. 1955.

Awajishima: Yura, *1398 b*, 13 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *386 b*, *408 c*, *410 a*, 22–23 May 1951.

Shima Peninsula: O-shima off Wagu, *824 d*, 5 Oct. 1952. Goza, *749 c*, 11 Jun. 1952.

Wakasa Bay: Koiso, Maizuru Bay, *1369 a*, 26 Nov. 1953. Nagahama, Maizuru Bay, *1580*, 10 Aug. 1954. *2111 a*, 30 Jun. 1956. *2142 a*, 31 Oct. 1957. Jyajima, Maizuru Bay, *2112 c*, 2 Jul. 1956. Kato, Obama Bay, *2669*, 20 Dec. 1959.

Hokkaido: Muroran, *1249 b*, 15 Jul. 1953.

Mastigocoleus testarum has been found perforating mollusk shells, corals and a calcareous alga Galaxaura, mostly associated with other perforating Cyanophyta (*Entophysalis deusta* and *Plectonema terebrans*) and Chlorophyta (*Gomontia polyrhiza*). Whenever we dissolve mollusk shells, corals, and calcareous algae coloured blue-green with hydrochloric acid or Pérényi's solution, we can see perforating algae, often of a few species mixed together.

The species inhabits not only living and dead mollusk shells, mostly of oysters, and corals, but also many corals, Corallinaceae, and lime stones. Although Okamura (1922) described that oysters for pearl-culture were often badly damaged by the growth of *Mastigocoleus testarum*, I have never found shells damaged by the alga;

and such an opinion was never expressed by fishermem when I visited pearl-culture farms at Ago Bay, Shima Peninsula. Okamura (1922) reported for the first time this species perforating mollusk shells in Japan.

Geographical distribution: In mollusk shells or in calcareous rocks and algae in marine water, rarely in fresh water ponds. Atlantic coast of Europe (Sweden, Baltic Sea, France, British Isles); Mediterranean (France, Adriatic Sea); North Africa (Egypt); Atlantic Ocean (Bermuda); Atlantic coast of North America (Prince Edward Island, Maine, Massachusetts, Rhode Island, Connecticut, North Carolina, Florida); Pacific coast of North America (California, Mexico); West Indies (Jamaica); Central America (Panama); Pacific Ocean (Society Islands); Southeast Asia (Indonesia); Indian Ocean (India).

Genus 2. **Brachytrichia**

Zanardini, Mem. Real. Istit. Veneto 17: 152, 1872.—Type species: *B. rivularioides* Zan.

Hormactis Thuret, Ann. Sci. Nat. VI. Bot. 1: 382, 1875.—Type species: *H. Balanii* Thur.

Plants minute or globose-cavernous, cartilaginous; filaments embedded in a firm, gelatinous matrix, loosely intertwined below, above becoming dense, erect, parallel, and attenuate towards the apices, branched; branching scytonematoid, Y-shaped, or laterally branched without loop-formation; sheaths distinct when young, later almost diffluent; heterocysts intercalary; reproduction by hormogones.

One species:

Brachytrichia Quoyi (Agardh) Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 373, 1886; Umezaki, Mem. Coll. Agr., Kyoto Univ., Special Number: 62, 1958; Okamura, Icones of Jap. Alg. 3: 137, pl. 133, figs. 14–17, 1915; Nippon Kaiso-shi, p. 911, fig. 427, 1936; Hirose, Biol. Journ. Okayama Univ. 3: 94, 1957.

Nostoc Quoyi Agardh, Syst. Algar., p. 22, 1824. *Hormactis Quoyi* Bornet in Farlow, Rep. U. S. Fish. Comm., p. 39, 1881. *Hormactis Farlowii* Bornet pro synon. in Farlow, Rep. U. S. Fish. Comm., p. 40, 1881.

Physactis Lloydii Crouan, Florule du Finistère, p. 117, 1867. *Rivularia Balanii* Lloyd pro synon. in Crouan l. c., 1867. *Hormactis Balanii* Thuret, Ann. Sci. Nat. VI. Bot. 1; 382, 1875. *Brachytrichia Balanii* Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 372, 1886.

Brachytrichia rivularioides Zanardini, Mem. Real. Istit. Veneto 17: 153, tab. 10, fig. A, 1-3, 1872.

Brachytrichia affinis Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 475, pl. 41, figs. 27, 28, 1918.

Brachytrichia Codii Setchell, Univ. Calif. Publ. Bot. 12: 66, 1926.

Brachytrichia Balanii f. *purpurea* Frémy, Compt. Rend. Acad. Sci. Paris 195: 1413, 1932.

Plants plicate or plicate-expanded, minute or large, up to 3 cm. in diameter, blackish-brown or blackish-green; filaments dense, compact above, below loosely complicate, flexuously curved; erect trichomes 5–6μ in diameter, lower ones more slender, above attenuating into long hairs, constricted at the cross walls; cells various in

shape, upper cells of the trichomes spherical, discoid, or up to 3 times as short as the diameter, the lower cells oblong or cylindrical; heterocysts larger than the vegetative cells, spherical or slightly depressed; hormogones single or two within a sheath, 20–25μ in length. Pl. 13.

Japanese name: Aimidori (Okamura 1915).

Habitat: Growing on rocks in the upper littoral belt, rarely among the utricles of Codium (*C. fragile*, *C. intricatum*, and *C. divaricatum*).

Amami Islands: Asani near Naze, O-shima, *1703*, 6 Apr. 1955. Gusuku, Sumiyo-mura, O-shima, *1724*, 7 Apr. 1955. Koniya, O-shima, *1768*, *1804*, 9–11 Apr. 1955. Naze, O-shima, *1852*, 12 Apr. 1955. *2182*, *2202*, 24 Jun. 1958. Akakina, Kasari-mura, O-shima, *1871*, 13 Apr. 1955. Kasari, O-shima, *2250*, 10 Jul. 1958. Tean near Koniya, O-shima, *2193*, 28 Jun. 1958. Urasokari near Koniya, O-shima, *2542*, 1 Jul. 1958. Ankyaba, Kakeroma-to, *2326*, *2493*, 30 Jun. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2044*, *2048 a*, 25 May 1956. Tomioka, Amakusa, *2007 a*, *2024*, 23–24 May 1956. Shingu, Fukuoka Pref., *1966 a*, *1967*, 20 May 1956. Tsuyasaki, Fukuoka Pref., *1984 a*, 21 May 1956.

Shikoku: Usa, Kochi Pref., *1450 a*, 16 Jun. 1954. Cape Muroto, *1457*, *1466*, 18 Jun. 1954. O-urasaki near Cape Ashizuri, *1473 a*, 19 Jun. 1954. Tsuro near Cape Ashizuri, *1493*, 20 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1528*, *1530*, *1533 a*, 23 Jun. 1954. *1688 a*, *1689*, 9 Feb. 1955. *1900*, *1949 a*, 4 Aug. 1955. Hon-jima, Shiaku Islands, *1543 a*, 23 Jun. 1954. *1923 a*, *1924*, *1948 b*, *1953*, 5 Aug. 1955.

Awajishima: Yura, *1393*, *1394 a*, *1395 a*, 13 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *64*, H. Utinomi, 20 May 1951. *370*, 21 May 1951. *568*, H. Utinomi, 29 Nov. 1951. *569*, H. Utinomi, 11 Dec. 1951. *573 a*, H. Utinomi, 30 Jan. 1952. *576*, H. Utinomi, 12 Feb. 1952. *578*, H. Utinomi, 18 Feb. 1952. *579*, H. Utinomi, 28 Feb. 1952. *645*, H. Utinomi, 29 Mar. 1952. *651*, H. Utinomi, 10 Apr. 1952. *653*, H. Utinomi, 15 Apr. 1952. *654*, H. Utinomi, 26 Apr. 1952. *655*, *656*, H. Utinomi, 9 May 1952. *675*, *676*, H. Utinomi, 22 May 1952. *754 a*, *755 a*, H. Utinomi, 9 Jun. 1952. *765*, H. Utinomi, 24 Jun. 1952. *767*, H. Utinomi, 18 Jul. 1952. *775*, H. Utinomi, 6 Aug. 1952.

Shima Peninsula: Wagu, *608 a*, 12 Mar. 1952. *708 a*, *714*, *715 a*, 9 Jun. 1952. O-shima off Wagu, *625*, 12 Mar. 1952. *726*, *731*, 10 Jun. 1952.

Aichi Pref.: Himaga-jima, Atsumi Bay, *343 b*, K. Inagaki, 21 Jul. 1948 (as *Brachytrichia Balanii* by Inagaki, 1950). Toyohama, Chita Peninsula, K. Okamura, Jul. 1902 (as *Brachytrichia Quoyi* in Okamura, Alg. Jap. Exsicc. no. 100, SAP).

Matsushima Bay: Katsura-shima, *1156 b*, *1169 a*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *959 b*, 24 Feb. 1953. *1280 d*, 31 Aug. 1953.

Wakasa Bay: Koiso, Maizuru Bay, *214 b*, 18 Aug. 1950. Takahama, Fukui Pref., *352*, 31 Jan. 1951. Kato, Obama Bay, *20*, 29 Jun. 1949. *56*, 8 Sept. 1949. *174*, 9 Jul. 1950. *194*, 7 Aug. 1950. *430 a*, 21 Jun. 1951. *581*, 2 Mar. 1952. *934 b*, 31 Dec. 1952. *969 b*, 28 Feb. 1853. *974 b*, 15 Mar. 1953. *1111 b*, 29 Apr. 1953. *1892*, 31 Jul. 1955. Tsunekami, Cape Tsunekami, *484 a*, *485*, 8 Aug. 1951.

Hokkaido: Muroran, *1388*, 21 Jul. 1947.

In my previous paper "Revision of Brachytrichia Zanard. and Kyrtuthrix Erceg." (1958) I combined all the species of Brachytrichia, which had been described and popularly used by many persons, into one species, *B. Quoyi* (Ag.) Born. & Flah.

Among the genera of Stigonemataceae the branching mode of filaments in

Brachytrichia is peculiar: 1), Mastigocoleus-like, without the formation of loops, the branches issue laterally from the parent trichomes; 2) Y-shaped branching, after the formation of loops, the branches issue at the apices of the loops, or normal branches are formed first and then loops are formed below them; and 3), scytonematoid branching, as seen in Scytonema, after loop-formation a loop-shaped apex ruptures and geminate branches are formed. The mode of branching is sometimes true or sometimes false.

Plants of this species have been found mostly on rocks in the upper littoral belt, rarely endophytic in Codium plants. Endophytic plants in Codium surely originate from plants growing on rocks (lithophytes).

The plants are very variable in size; in the Japanese specimens they range from microscopic to 3 cm. in diameter. Setchell & Gardner (1919) reported that Woods Hole specimens were sometimes 7 cm. in diameter. Okamura (1915, 36) and Fan (1953) described plants in Formosa measuring 5 cm. or more in diameter. Geographically the species is of subtropical or tropical rather than of temperate or subtemperate origin. The alga has been found commonly on the Japanese coast, from the Amami Islands to Hokkaido Island (Muroran). Geographically, in the warmer regions such as the Amami Islands, Kyushu, and Shikoku it is abundant and luxuriant in growth; whereas in the colder, northern districts such as Hokkaido and Matsushima Bay, it is rare in occurrence and the plants are small, up to 1 cm. broad. The plants from the Amami Islands are mostly 1–3 cm. broad.

The plants are cushion-shaped to spherical or bulbous, deeply or slightly plicate, or smooth on the surface. The plants with smooth surfaces grow generally on rocks exposed to direct sunlight during ebb tide, while the well plicate plants grow generally on rocks immersed in tide pools or in rock depressions kept ever during ebb tide. According to Utinomi's (1950) classification of marine biotic communities the former plants are xerophilic epibionts and the latter hydrophilic epibionts.

It has been well known that the colour of the blue-green algae shows a great variation. Lindstedt (1943) studied the colour of various species in culture and reported it to vary with changes in the environment. Most of the xerophilic epibiont forms of *B. Quoyi* are deep blue-green in colour, while the almost hydrophilic epibiont forms are brownish. The colour of the plant endophytic in Codium is variable also; some plants are blue-green and some purple. The vertical distribution of the species (and plants of one species) of Codium in the sea is very variable. Lindstedt (1943) and many other investigators reported that species of blue-green algae inhabiting deep waters or those cultured under weak light possess red or violet coloration. Thus it is natural to assume that the colour of *B. Quoyi* endophytic in Codium is variable.

In 1915 Okamura reported for the first time this species from the Japanese coast in his "Icones of Japanese Algae, Vol. 3."

Geographical distribution: Cosmopolitan (on rocks, barnacles, and larger algae in marine water, or in Codium).

Genus 3. **Kyrtuthrix**

Ercegović, Arch. f. Protistenk. 66 : 170, 1929.—Type species : *K. dalmatica* Erceg.

Plants irregularly or widely expanded, flat, crustaceous, thin, firm, composed of one layer of filaments ; filaments parallel, compact, usually attached at the middle with the both ends erect and oriented towards the surface of the plant, usually branched ; branching V-shaped ; sheaths firm, hyaline, above yellowish or light brown ; trichomes single within a sheath, above attenuated into a hair ; heterocysts intercalary ; reproduction by hormogones, rarely by spores.

One species :

Kyrtuthrix maculans (Gomont) Umezaki, Mem. Coll. Agr., Kyoto Univ., Special Number : 64, 1958 ; Hirose, Biol. Journ. Okayama Univ. 3 : 93, 1957.

Brachytrichia maculans Gomont, Bot. Tidsskrift 24 : 210, pl. 5, figs. 5–7, 1901 ; Okamura, Synopt. List Jap. Alg. 2nd ed., p. 266, 1916 ; Umezaki, Publ. Seto Mar. Biol. Lab. 5 : 418, 1956 ; Acta Phytotax. Geobot. 16 : 87, 1956.

Kyrtuthrix dalmatica Ercegović, Arch. f. Protistenk. 66 : 170, fig. 3, 1929 ; Umezaki, Publ. Seto Mar. Biol. Lab. 2 : 239, fig. 1, 1952 ; Journ. Jap. Bot. 30 : 60, 1955. *Brachytrichia dalmatica* Frémy, Mém. Soc. Nat. Sci. Nat. Math. de Cherbourg 41 : 162, pl. 51, fig. 2, 1934.

Plants blue-geen or blackish blue-green, when dried black, firm, widely expanded ; filaments 10–20μ in diameter, 100–400μ or rarely 500μ in height ; trichomes 4–9μ in diameter, above attenuated into hairs, constricted at the cross walls ; cells variable in shape, quadrate, cylindrical or barrel-shaped, 3–10μ in length ; heterocysts intercalary, nearly quadrate or a little longer, 6–11μ in diameter, 4.5–15.5μ in length ; hormogones single within a sheath, 17–35μ in length ; spores transform from the apical cells of filaments, 1.5–3μ in diameter. Pl. 14, fig. 1.

Japanese name : Iwasome-aimo (Umezaki 1955 a).

Habitat : Growing on rocks or pebbles in the upper littoral or supralittoral belt.

Amami Islands : Asani near Naze, O-shima, *1697*, *1699 a*, 6 Apr. 1955 (as *Brachytrichia maculans* by Umezaki, 1956 c). Yamma, Sumiyo-mura, O-shima, *1740*, *1747*, 8 Apr. 1955 (as *Brachytrichia maculans* by Umezaki, 1956 c). Naze, O-shima, *1854*, 12 Apr. 1955 (as *Brachytrichia maculans* by Umezaki, 1956 c). *2171*, 24 Jun. 1958. Akakina, Kasari-mura, O-shima, *1864 a*, *1867 a*, 13 Apr. 1955 (as *Brachytrichia maculans* by Umezaki, 1956 c). Gusuku, Sumiyo-mura, O-shima, *1719*, *1725*, 7 Apr. 1955. Sakihara, Kasari-mura, O-shima, *2441*, *2449*, 11 Jul. 1958. Kasari, O-shima, *2277*, 11 Jul. 1958. Koniya, O-shima, *1752 a*, *1774*, *1777*, *1797 b*, 10–11 Apr. 1955 (as *Brachytrichia maculans* by Umezaki, 1956 c). Ankyaba, Kakeroma-to, *2325*, *2500*, 30 Jun. 1958.

Kyushu : Cape Kaimon, Kagoshima Pref., *2065*, 26 May 1956. Tomioka, Amakusa, *2001*, *2005*, *2015*, *2019*, 22–23 May 1956. Shingu, Fukuoka Pref., *1973*, 20 May 1956.

Shikoku : Usa, Kochi Pref., *1428*, 15 Jun. 1954. Cape Muroto, *1453*, *1454*. 18 Jun. 1954. O-urasaki near Cape Ashizuri, *1479*, 19 Jun. 1954. Tsuro near Cape Ashizuri, *1492*, 20 Jun. 1954.

Shimonoseki : Yoshimi, *248*, 5 Nov. 1950.

Seto Inland Sea : Ozuchi-jima off Tamano, Okayama Pref., *1509*, 23 Jun. 1954. *1674 a*, 10 Feb. 1955. Hon-jima, Shiaku Islands, *1665*, 8 Feb. 1955.

Kii Peninsula: Seto, Shirahama, *382*, 22 May 1951 (as *Kyrtuthrix dalmatica* by Umezaki, 1952 a). *518*, *530*, *535*, *541*, 1 Nov. 1951 (as *Kyrtuthrix dalmatica* by Umezaki, 1952 a). *642*, 29 Mar. 1952 (as *Kyrtuthrix dalmatica* by Umezaki, 1952 a). Yuzaki, Shirahama, *504*, 31 Oct. 1951. Senjyojiki, Shirahama, *516*, 31 Oct. 1951. Hatake-jima, Tanabe Bay, *444*, 2 Aug. 1951.

Shima Peninsula: O-shima off Wagu, *624*, 12 Mar. 1952 (as *Kyrtuthrix dalmatica* by Umezaki, 1955 a). *803*, *804*, 5 Oct. 1952 (as *Kyrtuthrix dalmatica* by Umezaki, 1955 a). Wagu, *694*, 9 Jun. 1952. *802*, 4 Oct. 1952. Goza, *592*, *597*, 11 Mar. 1952 (as *Kyrtuthrix dalmatica* by Umezaki, 1955 a). Koshika, *603*, 11 Mar. 1952.

Izu Peninsula: Arashidomari near Shimoda, *835*, 8 Oct. 1952. Nagatsuro near Cape Iro, *885*, *891*, *893*, 10 Oct. 1952.

Mi-ura Peninsula: Jyogashima, *1045 a*, 30 Mar. 1953.

Boso Peninsula: Kominato, *1067*, 3 Apr. 1953. Futomi, *1094*, 4 Apr. 1953.

Matsushima Bay: Katsura-shima, *1162 c*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *1133*, 13 Jun. 1953.

Wakasa Bay: Koiso, Maizuru Bay, *664*, 23 May 1952. *1126*, 19 May 1953. Kanagamisaki, Maizuru Bay, *437*, 27 Jul. 1951. Sanbonmatsuhana, Maizuru Bay, *145*, 7 Apr. 1950. Takahama, Fukui Pref., *78*, 26 Sept. 1949. *103*, 22 Nov. 1949. *154*, 11 May 1950. *351 b*, 31 Jan. 1951. Wada, Fukui Pref., *90*, 14 Oct. 1949. *187*, 18 Jul. 1950. Kato, Obama Bay, *4*, *13*, 25 Jun. 1949. *46*, *51*, 8 Sept. 1949. *136*, *137*, 20 Mar. 1950. *175*, *176*, 9 Jul. 1950. *316*, 16 Dec. 1950. *360*, 1 Feb. 1951. *940*, 31 Dec. 1952. Obama, Obama Bay, *111*, 10 Dec. 1949. Tagarasu near Obama, *119*, 23 Dec. 1949. Tsunekami, Cape Tsunekami, *484 b*, 8 Aug. 1951. Kanagasaki, Tsuruga Bay, *164*, 28 May 1950. *197 b*, 4 Aug. 1950. *222*, *223*, 29 Sept. 1950. *769*, 26 Jul. 1952. Jyogu, Tsuruga Bay, *160*, *164*, 28 May 1950. Suizu, Tsuruga Bay, *165*, *166*, *167*, 30 May 1950. *227*, 30 Sept. 1950. *770*, 27 Jul. 1952.

Hokkaido: Muroran, *1229*, 14 Jul. 1953 (as *Brachytrichia maculans* by Umezaki, 1956 a). Oshoro, *330*, 3 Aug. 1947. *1250 a*, 17 Jul. 1953 (as *Brachytrichia maculans* by Umezaki, 1956 a). Rebun-to, *1316*, *1326*, *1328*, 31 Jul. 1953 (as *Brachytrichia maculans* by Umezaki, 1956 a).

I (Umezaki 1958) made a revision of the genus Kyrtuthrix and showed that *Brachytrichia maculans* Gom. (1807) was an earlier name for *Kyrtuthrix dalmatica* described by Ercegovič (1929).

The branching in Kyrtuthrix is peculiar; it was named V-shaped branching by me (1958). As in Brachytrichia loops are formed first, but they never break in two filaments and never form branches at the apex. Throughout the life of the plant the straight parts of the loop remain closely approximated.

On the Japanese coast *Kyrtuthrix maculans* has been found on rocks, mostly in the upper littoral belt, sometimes in the supralittoral belt.

This species, under the name of *Brachytrichia maculans*, was recorded for the first time for the Japanese marine flora in 1916 by Okamura, as occurring in Amakusa, Kyushu.

The plants are always plane as are those of *Isactis plana*, very firmly adhering to rocks, sometimes widely expanded. The colour is deep or blackish-blue-green, changing nearly black in drying. The colour is not so variable as in Brachytrichia, because the habitat-type is solely that of xerophilic epibiont of Utinomi (1950).

In addition to hormogones, spore-like cells have been found; the apical cells

of the trichome are successively transformed in spore-like rounded cells with a diameter of 1.5–3μ; they do not divide vertically.

Geographical distribution: On rocks or perforating calcareous rocks in marine water. Mediterranean (France, Dalmatian coast); Atlantic Ocean (Bermuda); Pacific Ocean (Hawaiian Islands); Southeast Asia (Indonesia, Viet Nam, Siam, Hong Kong); Indian Ocean (India).

Family 3. **Scytonemataceae**

Rabenhorst, Fl. Eur. Algar. 2: 2, 1865; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 5: 81, 1887; Drouet, Cyanophyta in Smith's Man. of Phyc., p. 164, 1951.—Type genus: *Scytonema* Ag.

Plants filamentous, or forming macroscopic strata or sphere; filaments mostly branched, rarely simple (Fremyella); branches false, solitary or geminate; sheaths firm, tubular, homogeneous or lamellate, hyaline or coloured; trichomes uniseriate, cylindrical, mostly single or rarely more within a sheath, of the same diameter throughout or slightly attenuate at the apices; cell divisions near the tips of the trichomes; heterocysts basal or intercalary, discoid, generally somewhat broader than the vegetative cells; reproduction by hormogones, rarely by spores.

Key to genera:

1. Filaments branched ..... 1. *Scytonema*
1. Filaments simple ..... 2. *Fremyella*

Genus 1. **Scytonema**

Agardh, Syst. Algar., p. 26, 1824; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 5: 85, 1887.—Type species: *S. Myochrous* Ag.

Plants floccose, intricate, expanded; filaments false-branched; branches usually arising between two heterocysts, solitary or geminate, formed by the lateral perforation of the sheath by the trichome; trichomes single within a sheath, straight; hormogones terminal, solitary.

One species:

Scytonema polycystum Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 5: 90, 1887; de Toni, Mem. R. Istit. Veneto 25: 66, 1895; Okamura, Synopt. List Jap. Alg. 1st ed., p. 220, 1902; 1, c. 2nd ed., p. 266, 1916; Matsumura, Index Plant. Jap. 1: 3, 1904; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 419, fig. 4, 1956.

Lyngbya effusa Harvey, Proc. Amer. Acad. 4: 334, 1859.

Plants floccose, intricate, 1 cm. broad, 1 cm. high, grayish-green; filaments 1 cm. long, 16–18–(22)μ in diameter, sparsely branched; branches geminate or single; sheaths membranaceous, thin, hyaline, not lamellate or only slightly lamellate; trichomes 10–15μ in diameter; cells 3–6μ in length, 1/3–1/4 as short as the diameter; heterocysts numerous, 7–12μ in length. Pl. 15, fig. 1.

Habitat: Growing on rocks or larger algae (Bostrychia and Galaxaura) in the upper littoral belt.

Amami Islands: Koniya, O-shima, *1758 a*, *1791*, 9-10 Apr. 1955. Tean near Koniya, O-shima, *2226*, 28 Jun. 1958. Kasari, O-shima, *2272*, Y. Yoneda, 11 Jul. 1958. Ushuku, Kasari-mura, O-shima, *2432*, 10 Jul. 1958. Ankyaba, Kakeroma-to, *2472*, 30 Jun. 1959. Ikeji, Kikai-jima, *1378*, 6 Jul. 1958. So-machi, Kikai-jima, *2394*, *2399*, 7 Jul. 1958.

Lyngbya effusa Harv., which was removed to *Scytonema polycystum* by de Toni (1895), was reported from Ryukyu by Harvey (1859), on the basis of specimens collected by C. Wright.

From the geographical distribution it seems to me that *S. polycystum* is of subtropical or tropical origin. On the Japanese coast it has been found only on the Amami Islands.

Geographical distribution: Among algae in marine water. Pacific Ocean (New Caledonia, Marshall Islands, Society Ialands); Southeast Asia (Indonesia).

Genus 2. **Fremyella**

J. de Toni, Noter. Nomencl. Algol., VIII, 1936.

Microchaete Thuret, Ann. Sci. Nat. VI. Bot. 1: 378, 1875; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 5: 83, 1887.—Type species: *M. grisea* Thur.

Plants small, aggregate in star-shaped or cushion-shaped tufts; filaments simple, differentiated into base and apex, erect, attached at the base; sheaths present; trichomes single within a sheath, never terminating in hairs; heterocysts basal and intercalary; reproduction by hormogones or by spores.

Key to species of Fremyella:

1. Filaments thickened at the bulbous bases; cells short..... 1. *F. grisea*
1. Filaments not or slightly thickened at the bases; cells long..... 2. *F. vitiensis*

1. **Fremyell grisea** (Thuret) J. de Toni, Noter. Nomencl. Algol., VIII, 1936.

Microchaete grisea Thuret, Ann. Sci. Nat. VI. Bot. 1: 378, 1875; Bornet & Thuret, Notes Algol. 1: 127, pl. 30, 1880; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 5: 85, 1887.

Plants small, aggregate; filaments decumbent at the base and slightly or bulbously thickened, above becoming erect, up to 300 μ in length, 6.5-9 (rarely -12) μ in diameter at the middle; sheaths hyaline, thin, close; trichomes blue-geen, 4.5-7 (raraly -8) μ in diameter; cross walls sometimes constricted; cells 2.5-5 μ in diameter, nearly quadrate or 2-(3) times as short as the diameter; heterocysts basal, single, hemispherical or nearly spherical; hormogones single within a sheath. Pl. 15, fig. 2.

Habitat: Growing on larger algae (Caulacanthus, Spyridia, Polysiphonia, Laurencia, Sphacelaria, Sargassum, and Boodlea).

Amami Islands: Seisui near Koniya, O-shima, *2206*, 29 Jun. 1958. Ushuku, Kasari-mura, O-shima, *2442*, 10 Jul. 1958.

Kyushu: Tsuyasaki, Fukuoka Pref., *2092*, 21 May 1956.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1516 c*, 23 Jun. 1954. Hon-jima, Shiaku Islands, *1551 a*, 24 Jun. 1954.

Shima Peninula : O-shima off Wagu, *821 b*, 5 Oct. 1952 (as *Fremyella aeruginea* by Umezaki, 1955 a).

Wakasa Bay : Takahama, Fukui Pref., *105*, 22 Nov. 1949.

Hokkaido : Lake Saroma, Kitami, *341 c*, K. Iwamoto, Aug. 1947.

Great variation, especially in size, has been found in the Japanese plants. The filaments are generally short, from 100μ to 300μ, longer ones never having been found ; and their diameter ranges from 6.5μ to 12μ in the middle portion, the base being generally much thickened, bulbous, and decumbent. The sheath is thin and closely fitted. The hormogones have been found forming even in the short filaments.

Geographical distribution : Subcosmopolitan (on larger algae and plants, or on rocks in marine water).

2. **Fremyella vitiensis** (Askenasy) J. de Toni, Noter. Nomencl. Algol., VIII, 1936 ; Umezaki, Publ. Seto Mar. Biol. Lab. 5 : 418, fig. 3, 1956.

Microchaete vitiensis Askenasy in Bornet & Flahault, Mém. Soc. Nat. Sci. Nat. Math. de Cherbourg 25 : 214, 1885 ; Ann. Sci. Nat. VII. Bot. 5 : 85, 1887.

Plants loose-caespitose ; filaments slightly or not at all thickened at the bases, above slightly attenuate, nearly straight or flexible, up to 600μ in length, 7–9.2μ in diameter at the middles ; sheaths hyaline, thin, close ; trichomes pale blue-green, (4.5)–5–6.1μ in dimeter at the middles, not constricted at the cross walls ; cells 2.5–6–(9)μ in length, quadrate or a little shorter or a little longer, or 1/2 as short as the diameter ; heterocysts basal, single, hemispherical. Pl. 14, fiig. 2.

Habitat : Growing on larger algae (Laurencia and *Gelidiella acerosa*).

Amami Islands : Koniya, O-shima, *1782 a*, 10 Apr. 1955. Sakihara, Kasari-mura, O-shima, *2467*, 11 Jul. 1958.

As known from the geographical distribution of *Fremyella vitiensis* the type locality of which is Viti Island in the Fiji Islands, Pacific Ocean, it is of a tropical origin.

The present specimens were collected on O-shima in the Amami Islands, a southernmost island in Japan and geographically located in the subtropical region. The longest filament is 600 μ, others being generally shorter. The filaments are sometimes slightly thickened at the base, but not so much as those of *F. grisea* which they resemble closely except for their longer cells.

Geographical distribution : On algae in marine water. Atlantic Ocean (Canary Islands, Bermuda) ; West Indies (Guadeloupe) ; Pacific coast of North America (Washington) ; Central America (Costa Rica) ; Pacific Ocean (Hawaiian Islands, Fiji Islands, Society Islands) ; Southeast Asia (Indonesia).

Family 4. **Rivulariaceae**

Rabenhorst, Fl. Eur. Algar. 2 : 2, 1865 ; Bornet and Flahault, Ann. Sci. Nat. VII. Bot. 3 : 338, 1886 ; Drouet, Cyanophyta in Smith's Man. of Phyc., p. 164, 1951.—Type genus : *Rivularia* Ag.

Plants developing as layers, cushions, spheres, or solitary filaments; filaments composed of sheaths and trichomes made up of single series of cells, differentiated into bases and apices, simple or branched; sheaths firm or more or less diffluent, homogeneous or lamellate; trichomes attenuate at the apices and ending in hairs, one to several within a sheath; heterocysts usually present, rarely absent, usually basal, occasionally intercalary; reproduction by hormogones, rarely by spores.

Key to genera:

1. Filaments free, not agglutinated in a gelatinous sheath..... 1. *Calothrix*
1. Filaments agglutinated in a gelatinous sheath..... 2
2. Plants dichotomously or irregularly branched..... 2. *Gardnerula*
2. Plants not branched..... 3
3. Plants plane; filaments mostly simple..... 3. *Isactis*
3. Plants hemispherical or globular; filaments repeatedly branched, oriented radially.. 4. *Rivularia*

Genus 1. **Calothrix**

Agardh, Syst. Algar., p. 24, 1824; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 3: 345, 1886.—Type species: *C. confervicola* Ag.

Plants developing as solitary filaments, as tomentose or pulvinate expansions, or as penicillate tufts; filaments simple or false branched; sheaths cylindrical, at first hyaline and homogeneous, later becoming very thick and lamellate; trichomes broad at the bases and gradually attenuated towards the apices, then ending in hyaline, multicellular, hair-like portions; heterocysts sometimes basal or sometimes intercalary, rarely absent, single or several in a series; reproduction by hormogones, rarely by spores.

Key to species of Calothrix:

1. Filaments simple, rarely branched, but not branching in a Scytonema-like fashion..... 2
1. Filaments branched, sometimes branching in a Scytonema-like fashion..... 5
2. Plants mostly endophytic; sheaths hyaline..... 3
2. Plants epiphytic or lithophytic; sheaths mostly coloured..... 4
3. Plants growing in Codium..... 1. *C. codicola*
3. Plants growing mostly in Nemalion, rarely in other gelatinous algae..... 2. *C. parasitica*
4. Plants growing on rocks; trichomes 7–13 μ in diameter..... 3. *C. scopulorum*
4. Plants growing on other algae; trichomes 10–18 μ in diameter..... 4. *C. confervicola*
5. Trichome ending in a long hair at the apex..... 5. *C. crustacea*
5. Trichome ending in a short hyaline hair or in a button-like cell at the apex..... 6. *C. pilosa*

1. **Calothrix codicola** Setchell & Gardner, Proc. Calif. Acad. Sci. IV, 19: 124, pl. 4, fig. 4, 1930; Umezaki, Journ. Jap. Bot. 28: 167, fig. 25 C, 1953.

Plants endophytic in Codium, mostly gregarious; filaments up to 500 μ in length, slightly thickened at the base, 9–15 μ in diameter at the bases; sheaths hyaline, thin, close-fitting throughout, smooth, homogeneous, rarely lamellate in the upper portion; trichomes 6.5–10 μ in diameter at the bases, very gradually attenuating towards the

apices and ending in short hairs, only at the base slightly constricted at the cross walls; cells a little longer or a little shorter than the diameter or up to 2 times as long as the diameter; protoplasm pale blue-green, homogeneous; heterocysts basal, rarely intercalary, 1–3 in a series, cylindrical, quadrate, hemispherical. Pl. 15, fig. 3.

Habitat: Growing among the utricles of Codium (*C. fragile*, *C. intricatum*, and *C. divaricatum*).

Amami Islands: Kasari, O-shima, *2265*, 11 Jul. 1958.

Kyushu: Tomioka, Amakusa, *2099 c*, 23 May 1956.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1533 b*, 23 Jun. 1954. *1949 b*, *1950*, 4 Aug. 1955. Hon-jima, Shiaku Islands, *1570*, *1574*, 23–24 Jun. 1955. *1612*, 29 Sept. 1954. *1952*, *1957*, *1958 a*, 6 Aug. 1955.

Amino: Amino Bay, Kyoto Pref., *959 a*, 24 Feb. 1953.

Wakasa Bay: Koiso, Maizuru Bay, *1127 a*, 19 May 1953. Takahama, Fukui Pref., *1373 c*, *1374 c*, 1 Dec. 1953. Kato, Obama Bay, *934 a*, 31 Dec. 1952. *969 a*, 28 Feb. 1953. *974 a*, 15 Mar. 1953. *1111 a*, 29 Apr. 1953.

The type specimen of *Calothrix codicola*, which grew among the utricles of *Codium fragile* in company with *Brachytrichia Quoyi* (*B. Codii* of Setchell), was collected by H. L. Mason on Guadalupe Island, Mexico, in 1925 and described as new by Setchell & Gardner in 1930. The Japanese plant has been found growing in *Codium fragile*, *C. intricatum*, and *C. divaricatum*, mostly in company with *Brachytrichia Quoyi*, *Microcoleus Voukii*, and *Hydrocoleum confluens*, generally sparsely represented.

Setchell & Gardner (1930) noted in the type description that there are differences between this species and *Calothrix parasitica* which it resembles; but my observations on the Japanese specimens suggest that the former is quite similar to the latter. However, I have dealt with the two as separate species in this paper, because the types have not been examined; further investigation is required.

Geographical distribution: Endophytic in Codium. North America (Mexico).

2. **Calothrix parasitica** (Chauvin) Thuret, Ann. Sci. Nat. VI. Bot. 1: 381, 1875; Bornet & Thuret, Notes Algol. 2: 157, pl. 37, figs. 7–10, 1880; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 3: 357, 1886; Yoneda, Acta Phytotax. Geobot. 9: 40, fig. 155, 1940; Umezaki, Journ. Jap. Bot. 28: 165, fig. 25 A, 1953; l. c. 30: 60, 1955; Publ. Seto Mar. Biol. Lab. 2: 240, 1952; l. c. 5: 416, 1956; Mem. Coll. Agr., Kyoto Univ. 66: 67, pl. 2, fig. 1, 1953; Acta Phytotax. Geobot. 16: 86, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957.

Calothrix nidulans Setchell & Gardner, Proc. Calif. Acad. Sci. IV, 12: 703, pl. 12, fig. 7, 1924; Umezaki, Acta Phytotax. Geobot. 16: 86, fig. 3 A, 1956.

Plants mostly endophytic in other algae or epiphytic on them, gregarious; filaments erect or curved, bulbous at the bases, not branching, 11–20–(25) μ in diameter at the bases, 7–12 μ in diameter at the middles; sheaths hyaline, thin, but slightly thickened near the bases, often dilated and funnel-shaped at the apices; trichomes blue-green or intense blue-green, slightly thickened at the bases, 8–15 μ in diameter

at the bases, 5–9 μ in diameter at the middles, above gradually attenuate and ending in very long, flexuous, hyaline hairs, slightly constricted or not at the cross walls; cells 2–3–(4) times as short as the diameter; heterocysts only basal, usually single or 2–3, hemispherical, spherical, or crescent-shaped; hormogones several within a sheath, 18–30 μ in length, 3–7 times as long as the diameter. Pl. 16. fig. 1.

Habitat: Growing in or on larger algae (Nemalion, Helminthocladia, Scytosiphon, Myelophycus, and Cutleria), or rarely on logs.

Amami Islands: Koniya, O-shima, *1778*, 10 Apr. 1955.

Kyushu: Tomioka, Amakusa, *2008 b*, 23 May 1956. Shingu, Fukuoka Pref., *1982*, 20 May 1956.

Kii Peninsula: Seto, Shirahama, *372*, *377*, *413*, 22 May 1951.

Shima Peninsula: O-shima off Wagu, *759*, 10 Jun. 1952. *820 b*, 5 Oct. 1952.

Matsushima Bay: Katsura-shima, *1164 a*, *1180*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *1138*, 13 Jun. 1953.

Wakasa Bay: Kanagamisaki, Maizuru Bay, *438*, 27 Jul. 1951. Nagahama, Maizuru Bay, *1960*, 22 Aug. 1955. Kato, Obama Bay, *8*, 22 Jun. 1949. *364*, 9 Jul. 1950. *425*, 21 Jun. 1951.

Hokkaido: Muroran, *574*, 31 Aug. 1947. Oshoro, *1263*, 27 Jul. 1953. Akkeshi, *1293*, 27 Jul. 1953 (as *Calothrix nidulans* by Umezaki, 1956 a).

The form of *Calothrix parasitica* endophytic in Nemalion is typical of the species, while that epiphytic on or endophytic in other algae than Nemalion (for example, Myelophycus, Cutleria, or Scytosiphon) or that on logs, is generally dwarf, a little shorter or smaller than the typical plants, although having its specific characteristics.

I have examined the type specimen of *Calothrix nidulans* Setch. & Gardn., which is preserved in the California Academy of Science, and have come to a conclusion that *C. nidulans* is a dwarf form of *C. parasitica* epiphytic instead of endophytic, although slightly immersed in the host. Therefore, I have combined *C. nidulans* with *C. parasitica*. In 1924 when *C. nidulans* was described, the authors asserted that *C. nidulans* is very close to *C. parasitica* although much smaller and without a hair at the apex of the trichome. In my examination of the type of *C. nidulans* I have found that the apex of the trichome sometimes ends in a diminutive but long hair.

The first record of this species for the Japanese marine Cyanophycean flora was made by Yoneda in 1940.

Geographical distribution: Subcosmopolitan (in Nemalion and other gelatinous marine algae).

3. **Calothrix scopulorum** (Weber & Mohr) Agardh, Syst. Algar., p. 70, 1824; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 3: 353, 1886; Okamura, Synopt. List Jap. Alg. 1st ed., p. 218, 1902; 1. c. 2nd ed., p. 266, 1916; Umezaki, Journ. Jap. Bot. 28: 165, fig. 25 B, 1953; 1. c. 30: 60, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 68, pl. 2, fig. 2, 1953; Acta Phytotax. Geobot. 16: 86, 1956; Publ. Seto Mar. Biol. Lab. 5: 416, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957.

Plants widely expanded, dark green or blackish strata; filaments yellowish-green, erect or slightly flexuous, up to 1 mm. in length, moderately thickened at the bases, 10–18–(20) μ in diameter at the middles; sheaths hyaline or light brown, somewhat thick, up to 4.5–(6) μ in thickness, repeatedly lamellate, dilated and expanded in the upper portion; trichomes yellowish-green or blue-green, 7–13 μ in diameter at the middles, above gradually attenuate, and then ending in long hyaline hairs, constricted at the cross walls, but usually not constricted in the upper portion of the trichome; cells nearly quadrate or 2–3–(4) times as short as the diameter; heterocysts basal, 1–5, crescent-shaped, spherical, or ellipsoidal; hormogones 1–3 or more within a sheath, 4–6 times as long as the diameter. Pl. 17, fig. 1.

Habitat: Growing on rocks or concrete in the supralittoral or upper littoral belt.

Amami Islands: Yamma, Sumiyo-mura, O-shima, *1746 a*, *1735 a*, 8 Apr. 1955 (as *Calothrix balearica* by Umezaki, 1956 c). Naze, O-shima, *2168 a*, 24 Jun. 1958. Akakina, Kasari-mura, *1868*, 13 Apr. 1955 (as *Calothrix balearica* by Umezaki, 1956 c). Ushuku, Kasari-mura, O-shima, *2435*, 10 Jul. 1958. Koniya, O-shima, *1759*, *1785 b*, *1788 a*, 9–11 Apr. 1955.

Kyushu: Cape Kaimon, Kagoshima Pref., *2057 b*, *2059 b*, *2063 a*, 26 May 1956. Ushinohama Kagoshima Pref., *2046*, 25 May 1956. Ao-shima, Miyazaki Pref., *2068 b*, *2070 a*, *2083 a*, 27 May 1956. Shingu, Fukuoka Pref., *1989*, 21 May 1956.

Shimonoseki: Yoshimi, *270 a*, *286 a*, 5 Nov. 1950.

Shikoku: Cape Muroto, *1461 b*, *1463 c*, 18 Jun. 1854.

Kii Peninsula: Seto, Shirahama, *390 a*, 22 May 1951. Wakanoura, Wakayama, *639 b*, 28 Mar. 1952.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1545 c*, *1571 a*, 23 Jun. 1954. *1626 b*, 30 Sept. 1954. *1671 a*, 9 Feb. 1955.

Shima Peninsula: O-shima off Wagu, *616*, 12 Mar. 1952. *725*, 10 Jun. 1952. *806 a*, 5 Oct. 1952. *748*, 11 Jun. 1952. Akogi-ura, Tsu, *678 a*, *679 b*, *680 a*, 7 Jun. 1952.

Enoshima: Enoshima, Kanagawa Pref., *1048*, *1050 b*, *1051 a*, *1053 a*, *1054 a*, 31 Mar. 1953.

Mi-ura Peninsula: Sendagasaki, Kurihama Bay, *998 a*, 28 Mar. 1953. Aburatsubo, *1005 a*, *1006 a*, *1014 a*, *1015*, *1017 a*, 29 Mar. 1953. Jyogashima, *1025 c*, *1040 a*, *1043 a*, 30 Mar. 1953.

Boso Peninsula: Kominato, *1068 a*, *1072 c*, *1080 a*, 3 Apr. 1953. Futomi, *1085 a*, *1100 a*, 4 Apr. 1953.

Matsushima Bay: Katsura-shima, *1163 a*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *780 b*, 24 Sept. 1952. *907*, 28 Oct. 1952. *954 a*, 29 Jan. 1953. *960*, 24 Feb. 1953. *1132 b*, 13 Jun. 1953.

Wakasa Bay: Koiso, Maizuru Bay, *37 a*, 10 Aug. 1949. *61*, 25 Sept. 1949. *97*, *98*, 11 Nov. 1949. *134 a*, *135*, 10 Mar. 1950. Obama, Obama Bay, *109 a*, 10 Dec. 1949. *237 a*, *239 a*, 14 Oct. 1950. Kato, Obama Bay, *55 b*, 8 Sept. 1949 (as *Calothrix balearica* by Umezaki, 1956). Tagarasu near Obama, *116 a*, 23 Dec. 1949. Kanagasaki, Tsuruga Bay, *218*, *221 a*, 29 Sept. 1950.

Aomori Pref.: No-ushi, Shimokita Peninsula, *2 a*, Y. Nakamura, 1 May 1949. Asamushi near Aomori, *1191*, 9 Jul. 1953.

Hokkaido: Muroran, *1213 a*, 14 Jul. 1953. Hariusu near Otaru, *331*, 13 Aug. 1947. Akkeshi, *1283*, *1285*, *1289*, *1291*, 26 Jul. 1953. Rebun-to, *1315 a*, *1317*, *1318 a*, *1319*, *1320 a*, *1321*, *1322*, *1323*, 31 Jul. 1953. Rishiri-to, *1340*, *1341*, *1344*, *1347 a*, *1348*, 2 Aug. 1953.

Calothrix scopulorum usually grows luxuriantly in cold water in the Arctic and north temperate regions. In Japan, it has also been found commonly distributed on the northern coasts, especially of Hokkaido where the plants were in best condition. The most abundant growth was found in the winter rather than during other seasons, although sometimes also during the summer season. This alga forms broad blackish strata mostly in the supralittoral belt with *Calothrix pilosa*. The filaments with intercalary heterocysts have been found sometimes growing in a mixture with normall filaments in which the heterocysts are only basal. Thus, *C. scopulorum* is to be considered as a growth form of *C. crustacea*, the heterocysts of which are both basal and intercalary. In the revisional work of the genus Calothrix, Fan (1956) considered that *C. scopulorum* is a growth form of *C. crustacea*. However, I have not yet reached the conclusion that the two should be treated as separate species in this paper, because there is a distinct ecological difference between the two and the filaments of *C. scopulorum* at hand never branch.

Specimens which have been referred to *Calothrix balearica* by me (1956, 56 c) seem to be of a dwarf form of *C. scopulorum*.

Geographical distribution: Cosmopolitan (on rocks, pebbles, concrete, wood, rarely on larger algae in marine and brackish waters).

4. **Calothrix confervicola** (Roth) Agardh, Syst. Algar., p. 70, 1824; Bornet & Thuret, Notes Algol. 1: 8, pl. 3, 1876; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 3: 349, 1886; Okamura, Synopt. List Jap. Alg. 1st ed., p. 218, 1902; 1. c. 2nd ed., p. 266, 1916; Umezaki, Acta Phytotax. Geobot. 16: 86, 1956; Publ. Seto Mar. Biol. Lab. 5: 416, 1956.

Calothrix nodulosa Setchell & Gardner, Proc. Calif. Acad. Sci. IV, 12: 702, pl. 12, figs. 9, 10, 1924; Umezaki, Journ. Jap. Bot. 28: 167, fig. 26 A, 1953; Mem. Coll. Agr., Kyoto Univ. 66: 68, pl. 3, fig. 2, 1953.

Plants gregarious, blackish-green or dirty green, rigid; filaments not branched, mostly up to 1 mm. or 1.5 mm. in length, sometimes slightly thickened at the bases, 18–28 μ in diameter at the middles; sheaths hyaline or yellowish, homogeneous or sometimes lamellate, up to 5 (rarely 8) μ in thickness; trichomes yellowish-green or blue-green, 10–18 μ in diameter at the middles, above ending in long hyaline hairs, not constricted at the cross walls; cells short, 2.5–4.5 μ in length, 3–5 times as short as the diameter; heterocysts basal, single or two, quadrate or a little longer, or hemispherical; hormogones numerous within a sheath, sometimes more than ten, 15–60 μ in length, 4–6 times as long as the diameter. Pl. 16, fig. 2.

Habitat: Growing on larger algae (Laurencia, Champia, Actinotrichia, Pterocladia, and Sargassum).

Amami Islands: Koniya, O-shima, *1782 b*, 10 Apr. 1955. Naze, O-shima, *2205*, 24 Jun. 1958. Akakina, Kasari-mura, O-shima, *2507*, 12 Jul. 1958.

Shikoku: Usa, Kochi Pref., *1448*, *1449*, 16 Jun. 1954.

Seto Inland Sea: Ozuchi-jima off Tamano, Okayama Pref., *1516 a*, *1531*, *1532 a*, 23 Jun.

1954. Hon-jima, Shiaku Islands, *1556 e*, 24 Jun. 1954.

Wakasa Bay: Kato, Obama Bay, *6 a*, 22 Jun. 1949 (as *Calothrix nodulosa* by Umezaki, 1953, 53 a).

Amino: Amino Bay, Kyoto Pref., *908*, 28 Oct. 1952.

Hokkaido: Oshoro, *1254 a*, 17 Jul. 1953.

The material from Kato, Obama Bay (my no. 6 a), which was reported as *Calothrix nodulosa* Setch. & Gardn. by me (1953, 53 a), is referred here to *C. confervicola*, young plants of which are very similar to those of the type specimen of *C. nodulosa* Setch. & Gardn. preserved in the Herbarium of California Academy of Science. Through the courtesy of Dr. J. T. Howell I have examined the type, to which most of the Japanese materials are quite similar. As mentioned above, these plants are dwarf, 1–1.5 mm. in length; *C. nodulosa* Setch. & Gardn. is a dwarf form of *C. confervicola*, typical plants of which are 2–3 mm. high, according to many reports.

Geographical distribution: Cosmopolitan (on larger algae in marine water).

5. **Calothrix crustacea** Thuret in Bornet & Thuret, Notes Algol. 1: 13, pl. 4, 1878; Bornet, & Flahault, Ann. Sci. Nat. VII. Bot. 3: 359, 1886; de Toni, Mem. Real. Istit. Veneto 25: 65, 1895; Okamura, Synopt. List Jap. Alg. 1st ed., p. 218, 1902; l. c. 2nd ed., p. 266, 1916; Matsumura, Index Plant. Jap. 1: 3, 1904; Umezaki, Journ. Jap. Bot. 28: 168, fig. 25 D, 1953; l. c. 30: 61, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 68, pl. 2, fig. 3 & pl. 3, fig. 1, 1953; Acta Phytotax. Geobot. 16: 86, 1956; Publ. Seto Mar. Biol. Lab. 5: 416, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957.

Leibleinia australis Kuetzing in Martens, Tange, p. 12, 1866.

Calothrix aeruginea Thuret, Ann. Sci. Nat. VI. Bot. 1: 382, 1875; Umezaki, Journ. Jap. Bot. 29: 173, fig. 37 A, 1954; l. c. 30: 60, 1955; Publ. Seto Mar. Biol. Lab. 5: 416, 1956.

Calothrix rectangularis Setchell & Gardner in Gardner, Univ. Calif. Publ. Bot. 6: 472, pl. 40, fig. 21, 1918.

Calothrix clausa Setchell & Gardner, Proc. Calif. Acad. Sci. IV, 19: 126, pl. 4, fig. 5, 1930.

Plants widely expanded, caespitose, blue-green or grass-green; filaments blue-green, straight or slightly curved, densely crowded, rarely branched in a Scytonema-like fashion, up to 2 mm. in length, a little thickened at the bases, 10–30–(40) μ in diameter at the middles; sheaths hyaline or light brown, when young thin, hyaline, later becoming thick and lamellate, or sometimes light brown, up to 7 (rarely 12.5) μ in thickness, variously dilated or expanded in the upper portions; trichomes olive-green or blue-green, 7–25 μ in diameter at the middles, thickened at the bases, above attenuating gradually and then ending in long, hyaline hairs, constricted or rarely not at the cross walls; cells 2–3 or 5 times as short as the diameter, upper cells generally short; heterocysts basal and intercalary, the basel ones 1–2, generally small, hemispherical, the intercalary ones several, scattered throughout the trichome, the young ones near the base, quadrate or cylindrical; hormogones several or sometimes up to ten within a sheath, 2.5–5 times as long as the diameter. Pl. 17, fig. 2 & pl. 18, fig. 1.

Japanese name: O-higemo (Umezaki 1955 a)

Habitat: Growing on rocks, concrete or mollusk shells along high tide level or in the upper littoral belt, sometimes on larger algae (Gelidium, Ulva, Hijikia, and Sargassum).

Amami Islands: Asani near Naze, O-shima, *1695 a*, *1698 a*, *1701 a*, 6 Apr. 1955 (as *Calothrix aeruginea* by Umezaki, 1956 c). Naze, O-shima, *1853 a*, 12 Apr. 1955. *2178*, 24 Jun. 1958. Akakina, Kasari-mura, O-shima, *1864 b*, *1867 b*, 13 Apr. 1955. Kasari, O-shima, *2273*, Y. Yoneda, 11 Jul. 1958. Gusuku, Sumiyo-mura, O-shima, *1721*, *1722*, *1729 a*, *1730*, 7 Apr. 1955. Yamma, Sumiyo-mura, O-shima, *1735 b*, *1746 b*, 8 Apr. 1955. Koniya, O-shima, *1790 a*, *1794 a*, *1810* (as *Calothrix aeruginea* by Umezaki, 1956 c), *1818*, 10–11 Apr. 1955. Tean near Koniya, O-shima, *2223*, *2233*, *2243*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2299*, 29 Jun. 1958. Ankyaba, Kakeroma-to, *2318*, *2321*, *2332*, *2338*, *2342*, 30 Jun. 1958. Ikeji, Kikai-jima, *2363*, 6 Jul. 1958. So-machi, Kikai-jima, *2386*, 7 Jul. 1958. Wan, Kikai-jima, *2423*, 8 Jul. 1958. Kametsu, Tokuno-shima, *2511*, *2518*, *2532*, 14 Jul. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2033 c*, *2034 a*, *2045*, *2047*, 25 May 1956. Tomioka, Amakusa, *2000 c*, *2003 a*, *2004*, *2013 a*, *2014*, *2016 b*, 23 May 1956. Ao-shima, Miyazaki Pref., *2071 a*, *2073 a*, *2075 a*, *2081 c*, 27 May 1956. Shingu, Fukuoka Pref., *1976*, 20 May 1956. Tsuyasaki, Fukuoka Pref., *1983 a*, *1992*, 21 May 1956.

Shimonoseki: Yoshimi, *252 a*, *254 a*, *257 a*, *265 a*, *270 b*, *273 a*, *281*, *283 a*, *289 a*, 5 Nov. 1950.

Shikoku: Katsurahama, Kochi, *1403 c*, 17 Jun. 1954. Usa, Kochi Pref., *1411 b*, *1412 b*, *1413 a*, *1414 a*, *1427 a*, *1432 a*, *1439 a*, *1441 b*, *1442 c*, 15–16 Jun. 1954. O-urasaki near Cape Ashizuri, *1469 b*, *1470*, *1474 a*, *1475 a*, *1478 a*, 19 Jun. 1954. Tsuro near Cape Ashizuri, *1491 b*, 20 Jun. 1954. Cape Muroto, *1455 a*, *1456 a*, 18 Jun. 1954.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1505*, 22 Jun. 1954. *1650*, *1651 a*, *1653*, *1654 a*, 8 Feb. 1955. *1896 a*, 4 Aug. 1955. Ozuchi-jima off Tamano, Okayama Pref., *1514 a*, *1524 b*, 23 Jun. 1954. *1598*, 29 Sept. 1954. *1680*, *1681 a*, *1692 a*, 10 Feb. 1955. *1908 a*, 5 Aug. 1955. Hon-jima, Shiaku Islands, *1541 b*, *1551 b*, *1552 a*, *1553 b*, *1568 a*, *1571 b*, *1573 a*, 23–24 Jun. 1954. *1627 c*, 30 Sept. 1954. *1672 a*, 9 Feb. 1955. *1935 a*, *1937 a*, 5 Aug. 1955.

Awajishima: Yura, *1395 c*, 13 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *386 a*, *394*, *398*, *399 a*, *401*, *408 a*, 23 May 1951. *452 b*, *463 b*, 3 Aug. 1951. *522 a*, *527*, 1 Nov. 1951. *546*, 2 Nov. 1951. Hatake-jima, Tanabe Bay, *446 a*, *451 a*, *467 a*, *470 a*, *471*, *473 b*, 2 Aug. 1951.

Shima Peninsula: O-shima off Wagu, *622 a*, *628*, 12 Mar. 1952. *706 a*, *729 a*, *733*, *735 a*, *738 a*, 10 Jun. 1952. *810 a*, *815 a*, *821 c* (as *Calothrix aeruginea* by Umezaki, 1954, 55 b), *823 a*, *824 c*, 5 Oct. 1952. Wagu, *609 a*, 12 Mar. 1952. *696 a*, *703 a*, *713 a*, 9 Jun. 1952. *795 a*, *801 a*, 4 Oct. 1952. Goza, *590 a*, *610 a*, 11 Mar. 1952. *749 a*, *750 a*, 11 Jun. 1952. Koshika, *602 a*, 11 Mar. 1952. Akogiura, Tsu, *691 b*, 7 Jun. 1952.

Izu Peninsula: Nagatsuro near Cape Iro, *886*, *887*, *889*, *892*, 10 Oct. 1952.

Mi-ura Peninsula: Aburatsubo, *1011 a*, *1013 a*, 29 Mar. 1953.

Matsushima Bay: Katsura-shima, *1157*, *1161 a*, *1164 b*, *1167 a*, 8 Jul. 1953.

Wakasa Bay: Kanmuri-jima off Maizuru Bay, *33*, 23 Jul. 1949. *2114 a*, 10 Oct. 1956. Sanbonmatsuhana, Maizuru Bay, *491 a*, *492*, 9 Oct. 1951. *777 b*, 16 Sept. 1953. Takahama, Fukui Pref., *74*, *75*, 26 Sept. 1949. *310 b*, 17 Nov. 1950. *346 a*, *351 a*, 31 Jan. 1951. *434*, 21 Jul. 1951. Wada, Fukui Pref., *91*, 14 Oct. 1949. Kato, Obama Bay, *47*, 8 Sept. 1949. *126*, 2 Jan. 1950. *355 a*, 1 Feb. 1951. *420*, 21 Jun. 1951. *564*, 10 Nov. 1951. *583 a*, *584*, *585*, 2 Mar. 1952. Tagarasu near Obama, *113*, *114*

a, *115 b*, 23 Dec. 1949. Tsunekami, Cape Tsunekami, *479*, *480*, 8 Aug. 1951. Suizu, Tsuruga Bay, *771 a*, 27 Jul. 1952. Kanagasaki, Tsuruga Bay, *225 a*, 29 Sept. 1950. Jyogu, Tsuruga Bay, *158 a*, *163*, 28 May 1950.

Aomori Pref.: Asamushi near Aomori, *1188 a*, *1190*, 9 Jul. 1953.

Hokkaido: Lake Saroma, Kitami, *341 a*, K. Iwamoto, Aug. 1947. Oshoro, *332 a*, 3 Aug. 1949. *1250 b*, 17 Jul. 1953. Muroran, *323 b*, 31 Aug. 1947.

Calothrix crustacea is commonly distributed on all the coasts of Japan, from the Amami Islands to Hokkaido Island. In the typical form the plant forms a stratum with a rounded margin up to 10 cm. or rarely more in diameter, coloured bright grass-green. The strata of *C. scopulorum* are, on the other hand, widely and irregularly expanded on rocks in the supralittoral belt; the margins are not rounded, and the colour is dark green or blackish-green. In the form growing on rocks the intercalary heterocysts are scattered through the entire trichome, from near the base to near the apex, whereas those of the form growing on other algae are found only near the base of the trichome, generally few in number, single or two together. In the type specimen of *C. rectangularis* Setch. & Gardn., which was found epiphytic on various marine algae in East Sound, Orcas Island, Washington, the intercalary heterocysts are formed only near the base of the trichome, according to the original figure and description. The epiphytic form of *C. crustacea* is quite similar to *C. rectangularis*, although the type has not been available for this study. However, I have considered here that *C. rectangularis* is an epiphytic form of *C. crustacea*. Moreover, I have learned from this study that *Calothrix aeruginea* Thur. is an epiphytic form of *C. crustacea* and in this respect I have agreed with Fan's work (1956) in which he has combined *C. aeruginea* with *C. crustacea*, considering it as a growth form of *C. crustacea*. In an examination of the type of *Calothrix clausa* Setch. & Gardn., which is preserved in the Herbarium of California Academy of Science, I have reached a conclusion that this species should be placed as a synonym of *C. crustacea* to which it is quite similar.

Geographical distribution: Cosmopolitan (on rocks and larger algae in marine water).

6. **Calothrix pilosa** Harvey, Nereis Bor.-Amer., III, p. 106, tab. 48 C, 1858; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 3: 363, 1886; Umezaki, Journ. Jap. Bot. 28: 168, fig. 26 B, 1953; Mem. Coll. Agr., Kyoto Univ. 66: 69, pl. 3, fig. 3, 1953; Publ. Seto Mar. Biol. Lab. 2: 241, fig. 2, 1952; l. c. 5: 417, 1956; Bot. Mag. Tokyo 68: 65, 1955.

Plants velvety, widely expanded, dark blue-green strata; filaments decumbent and densely interwoven at the bases, erect at the apices, elongate, rigid, 2–5 mm. or 1 cm. in length, 20–40–(45) μ in diameter, sometimes branched in Scytonema-like fashion, free or growing together laterally in fascicles; sheaths firm, hyaline when young, later becoming yellowish- or light brown, thick, up to 11 μ in thickness, lamellate; trichomes blue-green or bright blue-green, 15–28 μ in diameter, briefly attenuate

above, sometimes ending in a button-like apex, slightly constricted or not at the cross walls; cells nearly quadrate or 2–4 times as short as the diameter; heterocysts intercalary, several, cylindrical, quadrate, or flattened, 10–30 μ in length, of the same diameter as the trichome. Pl. 18, fig. 2.

Japanese name: Mosa-higemo (Umezaki 1955 a).

Habitat: Growing on rocks in the supralittoral belt, sometimes in the upper littoral belt.

Amami Islands: Koniya, O-shima, *1753 a*, *1807 a*, *1808 a*, 9–11 Apr. 1955. Tean near Koniya, O-shima, *2230*, 28 Jun. 1958. Akakina, Kasari-mura, O-shima, *1870 b*, 13 Apr. 1955. Kasari, O-shima, *2260*, Y. Yoneda, 11 Jul. 1958. Sakihara, Kasari-mura, O-shima, *2447*, 11 Jul. 1958. Urasokari near Koniya, O-shima, *2345*, Y. Yoneda, 1 Jul. 1958. Ikeji, Kikai-jima, *2384*, 6 Jul. 1958. Wan, Kikai-jima, *2405*, 8 Jul. 1958.

Tokara Islands: Nakano-shima, *1141*, E. Ogata, 5 Jun. 1953.

Kyushu: Ushinohama, Kagoshima Pref., *2030 a*, *2036 a*, 25 May 1956. Ao-shima, Miyazaki Pref., *2069*, 27 May 1956. Shingu, Fukuoka Pref., *1978*, 20 May 1956. Tsuyasaki, Fukuoka Pref., *1988 a*, *1991*, 21 May 1956.

Shimonoseki: Yoshimi, *268*, 5 Nov. 1950.

Seto Inland Sea: Hon-jima, Shiaku Islands, *1545 b*, *1546 a*, 24 Jun. 1954. *1615 a*, *1628 a*, 30 Sept. 1954. *1659 a*, *1664*, 8 Feb. 1955. *1916 a*, *1931 a*, 5 Aug. 1955. Tadano-umi, Hiroshima Pref., *301 a*, *303 a*, *304 a*, *305*, *307 a*, 8 Nov. 1950.

Kii Peninsula: Seto, Shirahama, *389*, 22 May 1951. *525*, *533 a*, *534*, 1 Nov. 1951. *646 a*, 29 Mar. 1952. Hatake-jima, Tanabe Bay, *441 a*, *472 a*, 2 Aug. 1951. Yuzaki, Shirahama, *500 a*, 31 Oct. 1951.

Izu Peninsula: Arashidomari near Shimoda, *834 a*, 8 Oct. 1952. Shimoda, *862*, *868 a*, *875*, 9 Oct. 1952. Nagatsuro near Cape Iro, *884 a*, 10 Oct. 1952.

Mi-ura Peninsula: Aburatsubo, *1012*, 29 Mar. 1953.

Boso Peninsula: Kominato, *1078 a*, *1088 a*, 3 Apr. 1953.

Amino: Amino Bay, Kyoto Pref., *932 a*, 25 Dec. 1952. *962 a*, 24 Feb. 1953. *1108 a*, 23 Apr. 1953. *1274*, 31 Aug. 1953. Hamazume near Amino Bay, *1381*, 19 Jan. 1954.

Wakasa Bay: Sanbonmatsuhana, Maizuru Bay, *1577 a*, 10 Aug. 1954. *1961 b*, 7 Nov. 1955. Takahama, Fukui Pref., *71*, 26 Sept. 1949. *129 a*, 15 Jan. 1950. *2608*, 3 May 1959. Aoshima, Obama Bay, *3*, 25 Jun. 1949. *55 a*, 8 Sept. 1949. Obama, Obama Bay, *110*, 10 Dec. 1949. *238*, 14 Oct. 1950.

Calothrix pilosa, a truly marine speceis, is commonly distributed on the Japanese coast. The plant grows generally in the highest zone in the intertidal belt, forming a widely expanded, velvety, dark blue-green stratum. The sheath is so variable in thickness that the dimensions of the filaments range from 20 μ to 45 μ. When young the sheath is thin and hyaline, but with age coloured yellowish or light brown and then thicker, sometimes 8–11 μ thick. Scytonema-like branching is characteristic for this species, although rare branching is found in *C. crustacea*.

Geographical distribution: Subcosmopolitan (on rocks in marine water).

Genus 2. **Gardnerula**

J. de Toni, Noter. Nomencl. Algol., VIII, 1936.

Polythrix Zanardini, Mem. Real. Istit. Veneto 17: 160, 1872; Bornet & Flahault, Ann. Sci.

Nat. VII. Bot. 3: 380, 1886.—Type species: *P. spongiosa* Zanard.

Plants filiform, branched, consisting of numerous filaments fasciculately aggregated within a gelatinous sheath; filaments densely crowded, repeatedly branched from the base upwards; heterocysts basal and intercalary.

One species:

Gardnerula corymbosa (Harvey) J. de Toni, Noter. Nomencl. Algol., VIII, 1936; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 294, fig. 1, 1956; 1. c. 5: 417, 1956; Journ. Jap. Bot. 31: 33, fig. 41, 1956.

Microcoleus corymbosus Harvey, Nereis Bor.-Amer., III, p. 109, pl. 48 B, 1858. *Polythrix corymbosa* Grunow in Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 3: 380, 1886.

Polythrix spongiosa Zanardini, Mem. Real. Istit. Veneto 17: 160, pl. 12, figs. 1-4, 1872.

Sirocoleum Jensenii Weber-van Bosse, Vidensk. Meddel. Dansk Naturk. Foren. 81: 68, figs. 5, 6, 1926.

Plants dark blue-green, mostly forming widely expanded, velvety strata on rocks, subdichotomously or irregularly branched, up to 7 mm. in length, 30–80μ in diameter at the basal portions, 60–300μ in diameter at the branched upper portions; gelatinous sheaths thick, somewhat gelatinous, rough on the outer surface, hyaline, but in the inner part yellowish or light brown, lamellate; filaments repeatedly branched within a gelatinous sheath, parallel; individual sheaths hyaline, but above often light brown, lamellate, dilated; trichomes blue-green, slightly thickened at the bases, 7–15 (mostly 9–12)μ in diameter at the bases, 5–12 (mostly 6–9)μ in diameter at the middles, above attenuated gradually or abruptly into long or somewhat short, hyaline hairs, constricted or not at the cross walls; cells generally short above, 3–7.5μ in length, 1–4 times as short as the diameter; heterocysts basal, often intercalary; the basal heterocysts single, 6.5–15μ in diameter, hemispherical, spherical, or ellipsoidal, the intercalary ones single, rarely two in series, mostly cylindrical or ellipsoidal, 10–25μ in length, a little broader than the diameter; hormogones one or two within a sheath, 15–30μ in length. Pl. 19.

Japanese name: O-higeso (Umezaki 1956 b).

Habitat: Growing on rocks along high tide level or in the upper littoral belt.

Amami Islands: Koniya, O-shima, *1787*, *1798 b*, *1799*, *1800*, *1801*, *1802*, 10-11 Apr. 1955. Tean near Koniya, O-shima, *2197*, 28 Jun. 1958. Seisui near Koniya, O-shima, *2301*, 29 Jun. 1958. Kasari, O-shima, *2253*, Y. Yoneda, 10 Jul. 1958.

Kii Peninsula: Seto, Shirahama, *550*, 2 Nov. 1951.

J. de Toni (1936) published the name Gardnerula to supplant the homonymous Polythrix G. Zanardini (1872). The type of the genus Polythrix is *P. spongiosa*, the original material of which was discovered at Singapore. Before the genus Polythrix was established, Harvey (1858) described *Microcoleus corymbosus* as a new species in his "Nereis Boreali-Americana," Part III. Afterwards, Bornet & Flahault (1886), noting that the original specimens of these two species were the same, made the new combination *Polythrix corymbosa* Grun. in their "Revision des Nostocacées Hétéro-

cystées."

Since then a little attention has been attracted to the genus Polythrix by phycologists in general, except by Tilden (1910), Collins & Hervey (1917), Taylor (1928), Gardner (1932), Geitler (1932), Poljansky (1937), Drouet (1951), and Friedmann (1956). Among them, recently Friedmann (1956) made a detailed morphological observation on this species which grew on the Israel coast. Weber-van Bosse (1926) described a new species, *Sirocoleum Jensenii*, trichomes of which are distinctly attenuated into hairs at the apices and possess cylindrical heterocysts. Afterwards, as mentioned above, when the genus Gardnerula was published, J. de Toni listed *Sirocoleum Jensenii* Weber-van Bosse as well as *Microcoleus corymbosus* Harvey, *Polythrix spongiosa* Zanard. and *P. corymbosa* Grunow as synonyms of *Gardnerula corymbosa*.

I have colleted this species at Shirahama on the Kii Peninsula, the middle of the Pacific coast of Honshu, and on the Amami Islands. The plant from Shirahama was found growing among other blue-green algae mixed with sand on rocks in the upper littoral belt. The plants were yet young and small, only 150-1300μ high. But the trichomes were rather thick, 7.5-16.5μ in diameter at the bases and 4.5-12μ at the middles. On the other hand, the plants from the Amami Islands were found growing on rocks along high tide level or in the upper or lower littoral belts, forming velvety strata widely expanded; they were mostly 4-7 mm. in height, well matured, with abundant hormogones formed in the apical portions of the branches. In size the plant from the Amami Islands corresponds with that of the description of *Microcoleus corymbosus* by Harvey and of *Sirocoleum Jensenii* by Weber-van Bosse. The diameters of the trichomes are 7-15μ, mostly 9-12μ at the bases, and 5-13μ, mostly 6-9μ at the middles. On the whole, the Amami Islands specimens, except for the height of plant, are much the same as those of Shirahama. Zanardini's original diagnosis of *Polythrix spongiosa* is as follows: "Frondibus lineam altis, 1/40''' crassis; filis tenuissimis, 1/900''' crassis." According to Harvey the plant of *Microcoleus corymbosus* is from an eighth to a quarter of an inch in length. In the diagnosis of *Polythrix corymbosa*, Bornet & Flahault (1886) described that the plants are 1-3 cm. high and the trichomes 5-6μ in diameter. In *Sirocoleum Jensenii* the plants are 1 cm. high, the filaments 120-260μ broad, and the trichomes 3.6-5.4μ, rarely 7.2μ broad. In Israel specimens the basal portions of the trichomes are (1.6)-2-5-(6.8)μ in diameter and the upper meristematic portions 4-7.2μ in diameter, according to Friedmann (1956). Generally in the Japanese specimens the trichomes are somewhat thicker than those of the foreign specimens mentioned above. I have received many specimens of this species collected in Bermuda, Jamaica, Israel, the Hawaiian Islands and the Philippines from Dr. Drouet; with them the Japanese specimens accord very well in the several characters. All of these plants are up to 4 mm. high, and the trichomes 3-12 (mostly 5-7.5)μ in diameter at the middles. In both the Shirahama and the Amami Islands specimens the intercalary heterocysts

are formed not only in the old plants but also in the young ones, and they are mostly cylindrical, rarely quadrate in shape, having the length of 10–25μ. As the Amami Islands plands are adult and well matured, numerous hormogones are formed at the apical portion of the branches, single or two within the sheath, short- or long-cylindrical. Because they are young, the Shirahama plants do not possess hormogones.

It appears that the reproduction of this species is effected by the formation of hormogones and perhaps by the fragmentation of branches; the small branches of the filaments become detached from the main filaments and grow in new individuals.

Systematically the genus Gardnerula may be placed between Rivularia and Dichothrix rather than between Dichothrix and Calothrix because the repeatedly branched filaments radiate from the base upwards within a gelatinous sheath. But Gardnerula is considered to be quite distinct from Rivularia because of its peculiarly branched plants. It differs from Dichothrix in its simple structure and in the compact arrangement of its numerous filaments within a gelatinous sheath.

In consideration of its geographical distribution, it is probably of tropical origin, since it is found chiefly in tropical or rarely in the subtropical regions.

Geographical distribution: On rocks in marine water. Mediterranean (Israel); Atlantic coast of North America (Florida); Atlantic Ocean (Bermuda); West Indies (Jamaica, Puerto Rico); Pacific Ocean (Hawaiian Islands, Tongataba Island, New Caledonia Island, Kei Island); Southeast Asia (Philippines, Malaya, Indonesia).

Genus 3. **Isactis**

Thuret, Ann. Sci. Nat. VI. Bot. 1: 382, 1875; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 343, 1886.—Type species: *I. plana* Thur.

Plants flat, crustaceous, orbicular, thin, adhering by the lower surfaces; filaments erect, densely crowded and coalescent in a compact layer, simple or sparsely branched; heterocysts basal; reproduction by hormogones; spores unknown.

One species:

Isactis plana (Harvey) Thuret, Ann. Sci. Nat. VI. Bot. 1: 382, 1875; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 344, 1886; Umezaki, Journ. Jap. Bot. 28: 169, fig. 27, 1953; l. c. 30: 61, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 69, pl. 4, fig. 1, 1953; Publ. Seto Mar. Biol. Lab. 2: 242, 1952; l. c. 5: 417, 1956; Acta Phytotax. Geobot. 16: 86, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957.

Plants crustaceous, expanded indefinitely on rocks, usually less than 3 cm. in diameter or sometimes more, dark blue-green, when dried black, 150–550μ in height; filaments densely crowded; sheaths thick, hyaline, but above sometimes light brown and dilated, lamellate; trichomes blue-green or light blue-green, 6–10–(14)μ in diameter at the bases, 5–8μ in diameter at the middles, above attenuated gradually, and then ending in delicate, hyaline hairs, constricted at the cross walls; cells nearly

quadrate or 2-(3) times as short as the diameter; protoplasm homogeneous or sometimes with large granules; heterocysts basal, 1-3, hemispherical or depressed-crescent-shaped; hormogones 1-2 within a sheath. Pl. 20, fig. 1.

Japanese name: Iwano-aza (nom. nov.).

Var. **plana**

Plants not zonate; filaments unbranched or nearly so, cohering together.

Var. **fissurata** Bornet & Flahault, l. c. 345, 1886.

Plants more or less zonate; filaments false-branched, tightly cohering.

Habitat: Growing on rocks, pebbles or mollusks in the upper or lower littoral belt, rarely epiphytic on larger algae.

Amami Islands: Koniya, O-shima, *1761*, *1785 c*, *1788 b*, 9-10 Apr. 1955. Tean near Koniya, O-shima, *2238*, 28 Jun. 1958. Ankyaba, Kakeroma-to, *2322*, *2343*, 30 Jun. 1958. So-machi, Kikai-jima, *2400*, 7 Jul. 1958.

Kyushu: Shingu, Fukuoka Pref., *1966 a*, 20 May 1956. Tsuyasaki, Fukuoka Pref., *1986*, *1997*, *1998*, 21 May 1956.

Shimonoseki: Yoshimi, *250*, *251*, *258*, *267*, *274*, *276*, *277*, *280*, *282*, *287*, 5 Nov. 1950.

Shikoku: Usa, Kochi Pref., *1438*, 16 Jun. 1954. Cape Muroto, *1460*, *1461 a*, *1465 b*, 18 Jun. 1954.

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1499*, *1502*, 22 Jun. 1954. *1894*, *1897*, 4 Aug. 1955. Ozuchi-jima off Tamano, Okayama Pref., *1510*, *1517*, 23 Jun. 1954. *1590*, *1595*, *1597*, 29 Sept. 1954. *1675*, *1678*, *1691 a*, 10 Feb. 1955. *1899 b*, *1904*, 5 Aug. 1955. Hon-jima, Shiaku Islands, *1535*, *1541 a*, *1542 a*, *1554 b*, *1556 c*, *1558 a*, *1571 c*, *1573 b*, *1575 b*, 23-24 Jun. 1954. Fukuyama, Hiroshima Pref., *2651*, T. Inumaru, 18 Jul. 1959.

Awajishima: Yura, *1394 c*, 13 Jun. 1954.

Kii Peninsula: Seto, Shirahama, *373 b*, *375*, *376*, *383*, *397*, *402*, 22 May 1951. *539*, *542*, *543*, 2 Nov. 1951. *643*, 29 Mar. 1952. Yuzaki, Shirahama, *507*, *508*, 31 Oct. 1951. *2692*, 9 Jun. 1960. Kashima, Tanabe Bay, *448*, 2 Aug. 1951.

Shima Peninsula: O-shima off Wagu, *615*, *619*, *621*, 12 Mar. 1952. *732 a*, *735 b*, *736*, 10 Jun. 1952. Goza, *600*, 11 Mar. 1952. *744*, *745*, 11 Jun. 1952. Wagu, *707*, *709*, 9 Jun. 1952. *796*, *798 b*, 4 Oct. 1952. Koshika, *605*, 11 Mar. 1952.

Izu Peninsula: Shimoda, *865*, 9 Oct. 1952.

Boso Peninsula: Kominato, *1070 a*, *1083*, 3 Apr. 1953. Futomi, *1093*, 4 Apr. 1953.

Matsushima Bay: Katsura-shima, *1155*, *1162 b*, *1168 a*, *1169 b*, 8 Jul. 1953.

Amino: Amino Bay, Kyoto Pref., *906*, 28 Oct. 1952. *1109*, 23 Apr. 1953. *1282*, 31 Aug. 1953.

Wakasa Bay: Kanmuri-jima off Maizuru Bay, *32*, 23 Jul. 1949. *659*, 18 May 1952. *1887*, 19 May 1955. *2115*, 10 Oct. 1956. Koiso, Maizuru Bay, *38*, 10 Aug. 1949. *66 a*, *67*, 25 Sept. 1949. *214 a*, *215*, *216*, 18 Aug. 1950. Toshima, Maizuru Bay, *40*, 13 Aug. 1949. *79*, *80*, 30 Sept. 1949. Kanagamisaki, Maizuru Bay, *435*, 27 Jul. 1951. *673*, 23 May 1952. Kanzaki, Kunda Bay, *84 a*, *85 a*, *86 a*, 30 Sept. 1949. *172*, 30 Jun. 1950. Takahama, Fukui Pref., *72*, *73*, 26 Sept. 1949. *185*, *186*, 18 Jul. 1950. *309*, 17 Nov. 1950. *348*, 31 Jan. 1951. *432*, *433*, 21 Jul. 1951. Kato, Obama Bay, *48*, *49*, *50*, *52 a*, 8 Sept. 1949. *124*, 2 Jan. 1950. *138*, *142*, 20 Mar. 1950. *191*, *192*, 7 Aug. 1950. *314*, *315*, 16 Dec. 1950. *354*, *361*, 1 Feb. 1951. *427*, *428*, *429*, 21 Jun. 1951. *1114*, 29 Apr. 1953. *1121*, 12 May 1953. Obama, Obama Bay, *231*, *243*, 14 Oct. 1950. Tagarasu near Obama, *117*, *118*, *120 b*, 23 Dec. 1949.

Tsunekami, Cape Tsunekami, *475*, *477*, *478*, *481*, *482*, 8 Aug. 1951. Kanagasaki, Tsuruga Bay, *195*, *196*, *198*, 4 Aug. 1950. *768*, 26 Jul. 1952. Suizu, Tsuruga Bay, *205*, 5 Aug. 1950. *226*, 30 Sept. 1950.

Hokkaido: Muroran, *1216*, *1220*, *1240*, 14-15 Jul. 1953. Oshoro, *1259*, 17 Jul. 1953. Akkeshi, *1284*, *1288*, *1290*, *1295*, *1296*, *2199*, *1300*, 27-28 Jul. 1953. Rebun-to, *1329*, *1330*, *1332*, 1 Aug. 1953. Rishiri-to, *1336*, *1339*, *1342*, 2 Aug. 1953.

Isactis plana is one of widespread species on our coasts and a truly marine species. It grows on rocks, pebbles or mollusk shells in the littoral belt, mostly in the upper littoral belt, forming pure strata, although *Entophysalis deusta* or an elongated form of *Plectonema calothrichoides* rarely grow among the filaments. The plants show great variation in height, ranging from 130μ to 550μ; superficially they resemble plants of *Kyrtuthrix maculans* which range from 100μ to 500μ in height. In Australian specimens the plants are 0.4–0.9 mm. in height, according to Womersley (1946), who mentions that its great thickness is a noticeable difference from that of Northern Hemisphere specimens. Var. *fissurata*, plants of which are zonate, mostly in two zones, is not always higher as compared with the var. *plana* to which most of the Japanese plants belong. The trichomes are generally torulose, but sometimes slightly or not at all constricted at the cross walls. The cells of the basal portion of the trichome are nearly quadrate and those of the middle and upper portions more shorter, generally 1/2–1/3 as short as the diameter. I have met with cells 1.5–2 times as long as the diameter, in seemingly adult plants. In the adult and decaying plants there are often formed intercalary heterocysts. Such intercalary heterocysts, although seemingly abnormal, have also been found in *Rivularia atra* and *R. polyotis*.

Geographical distribution: Cosmopolitan (on rocks, pebbles, and larger algae in marine water).

Genus 4. **Rivularia**

C. Agardh, Syst. Algar., p. 19, 1824; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 345, 1886.—Type species: *R. atra* Roth.

Plants hemispherical, globose, or irregularly lobed, pale to dark green, firm or soft-gelatinous, at times hollow or confluent in a solid expanded mass; filaments radiating from the center or from the base, repeatedly false-branched; heterocysts basal (or rarely intercalary).

Key to species of Rivularia:

1. Plants soft; filaments readily separable under pressure. ..... 1. *R. polyotis*
1. Plants hard; filaments not readily separable under pressure 2
2. Plants hollow ..... 2. *R. nitida*
2. Plants solid ..... 3. *R. atra*

1. **Rivularia polyotis** (Agardh) Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 360, 1886; Umezaki, Publ. Seto Mar. Biol. Lab. 5: 417, fig. 2, 1956.

Plants very soft, hemispherical, pulvinate, up to 1.5 cm. in diameter, but later becoming mostly confluent and hollow, dark or pale olive-green; filaments readily separable under pressure; sheaths thick, hyaline or pale brown, lamellate, ocreate, above dilated; trichomes 2.5–5μ in diameter in the lower portion of the plant, 8.5–12μ in diameter in the meristematic region, then attenuating into a moderately thick hair, slightly or not at all constricted at the cross walls; cells in the meristematic region 3–9μ in length, 1–4 times as short as the diameter, cells in the lower portion 12–30–(40)μ in length, 3–8–(10) times as long as the diameter; heterocysts basal, rarely intercalary; the basal heterocysts spherical or ovoid, 9–18μ in diameter; the intercalary ones ovoid to oblong-cylindrical, 6–9μ in diameter, 12–21μ in length. Pl. 20, fig. 2.

Japanese name: Nebari-riburaria (nom. nov.).

Habitat: Growing on rocks in the upper littoral belt.

Amami Islands: Koniya, O-shima, *1796 a*, 11 Apr. 1955. Tean near Koniya, O-shima, *2198*, *2282*, 28 Jun. 1958. Akakina, Kasari-mura, O-shima, *1870 a*, 13 Apr. 1955. Kasari, O-shima, *2251*, Y. Yoneda, 10 Jul. 1958. Ikeji, Kikai-jima, *2383*, 6 Jul. 1958. Wan, Kikai-jima, *2414*, 8 Jul. 1958.

Rivularia polyotis has been found only on the Amami Islands, not in other regions of the Japanese coast. The plants have mostly formed confluent masses on rocks in the upper littoral belt where they and those of *Gardnerula corymbosa* grew together.

R. polyotis is to be distinguished from the other two species *R. atra* and *R. nitida*, by its soft body in which the filaments do readily separate under pressure, by its wide trichomes and by its wide lamellate sheaths. The plants from the Amami Islands are up to 1.5 cm. in diameter, smaller as compared with those of other parts of the world. In Bornet & Flahault's description the plants are said to be up to 3 cm. broad and Womersley's measurements (1946) are up to 8 cm. broad. But the present plants were found forming confluent masses widely expanded on rocks. The cells in the meristematic region of the plant are short, while the lower ones are longer, 12–30–(40)μ long or 3–8–(10) times as long as the diameter. Such long cells have never been reported by any other person: Bornet & Flahault's description is "cellulis inferioribus diametro subduplo longioribus"; and Womersley's diagnosis is "lower cells becoming longer." Intercalary heterocysts are rarely formed; they are 6–9μ by 12–21μ, somewhat narrower in diameter as compared with the basal heterocysts.

Geographical distribution: Subcosmopolitan (on rocks and pebbles, or on other algae in marine water).

2. **Rivularia nitida** Agardh, Dispositio Algar. Sueciae, p. 44, 1812; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 357, 1886; Umezaki, Journ. Jap. Bot. 29: 175, fig. 37 c, 1954; Mem. Coll. Agr., Kyoto Univ. 66: 70, pl. 4, fig. 3, 1953; Dawson, Pacific Naturalist 1(5): 29, 1959.

Plants dark blue-green, cartilaginous, usually hollow, variable in outline, plicate-corrugate, solitary or occasionally confluent, up to 1 or 2 cm. in diameter; filaments crowded, tight-parallel; sheaths hyaline, thin, close fitting below, above pale brown and dilated, prominent, distinct, but indistinct below, 3.5–7.5μ in diameter in the upper portion, then prolonged in long, hyaline hairs, slightly constricted or sometimes not at the cross walls; cells 2.5–9μ in length, 0.5–3 times as long as the diameter, generally short above; heterocysts basal, single, spherical or hemispherical, 5–15μ in diameter; hormogones single within a sheath, 21.5–29μ in length, 5–6.5 times as long as the diameter. Pl. 21, fig. 1.

Japanese name: Ana-riburaria (nom. nov.).

Habitat: Growing on rocks along high tide level or a little below.

Amino: Amino Bay, Kyoto Pref., *1276*, 31 Aug. 1953.

Wakasa Bay: Obama, Obama Bay, *241*, 14 Oct. 1950. Aoshima, Obama Bay, *562 b*, 10 Nov. 1952. Kato, Obama Bay, *342*, 29 Apr. 1949. *358*, 1 Feb. 1951. *588*, 2 Mar. 1952. *941*, 31 Dec. 1952. *946 b*, 25 Jan. 1953. *968*, 28 Feb. 1953. Takahama, Fukui Pref., *344 a*, 31 Jan. 1951. Kanagasaki, Tsuruga Bay, *772*, 26 Jul. 1952.

Matsushima Bay: Katsura-shima, *1156 a*, 8 Jul. 1953.

Aomori Pref.: Sawabe, Nishitsugaru-gun, *572*, H. Ohmi, 17 Nov. 1951. Fukaura, Nishitsugaru-gun, *2134*, S. Kawashima, 1 Nov. 1956.

Hokkaido: Wakkanai, *1352*, Y. Sakai, 20 Jul. 1951.

According to Bornet & Flahault (1886) the plants measure up to 3 cm. in diameter, whereas the Japanese specimens are generally smaller, up to 1 or 2 cm. The Japanese specimens closely resemble Womersley's (1946) South Australia plants which measure 2 cm., although he described his specimens as having a little thicker trichomes than the Northern Hemisphere plants. The cells in the lower portion of the trichome are generally longer, up to 3 times as long as the diameter, According to Bornet & Flahault they are described to be 3 or 4 times as long as the diameter. Womersley said they are often longer.

The Japanese plants have been found in colder water regions, occurring in Amino Bay and Wakasa Bay on the Japan Sea coast and in Matsushima Bay, Aomori Prefecture, and on Hokkaido in the northern district of Japan. The geographical distribution of the species is in temperate, subarctic or arctic regions, generally in colder waters.

Geographical distribution: Cosmopolitan (on rocks in marine and brackish waters).

3. **Rivularia atra** Roth, Catalecta Botanica, III, p. 340, 1806; Bornet & Flahault, Ann. Sci. Nat. VII. Bot. 4: 353, 1886; Okamura, Synopt. List Jap. Alg. 1st ed., p. 218, 1902; 1. c. 2nd ed., p. 266, 1916; Matsumura, Index Plant. Jap. 1: 3, 1904; Umezaki, Journ. Jap. Bot. 29: 175, fig. 37 B, 1954; 1. c. 30: 61, 1955; Mem. Coll. Agr., Kyoto Univ. 66: 70, pl. 4, fig. 2, 1953; Publ. Seto Mar. Biol. Lab. 2: 243,

1952; l. c. 5: 417, 1956; Acta Phytotax. Geobot. 16: 87, 1956; Tanaka, Mem. South. Ind. Sci. Inst. 1: 17, 1956; Hirose, Biol. Journ. Okayama Univ. 3: 93, 1957.

Rivularia opaca Harvey, Proc. Amer. Acad. 4: 334, 1859; pro synon. in de Toni, Mem. Real. Istit. Veneto 25: 65, 1895.

Plants blackish blue-green, hard, hemispherical or flat, solitary or confluent, 2–5 mm. in diameter; filaments repeatedly branched from the base upwards and radially dense and compact; sheaths thin, generally obscure, above yellowish and dilated, below generally thick; trichomes blue-green, below slender, 2–3.5μ in diameter, above a little thicker, 4–6μ in diameter, then ending in long, hyaline hairs, not constricted at the cross walls, but below slightly constricted; cross walls indistinct below, but the upper cells of the trichome distinct; cells in the meristematic region 2–3μ in length, 1–1/3 time as long as the diameter, lower cells longer, 7.5–18μ, rarely 33μ in length, 3–6 (rarely 11) times as long as the diameter; heterocysts basal, single, spherical, sometimes ellipsoidal, 5–11–(15.5)μ in diameter. Pl. 21, fig. 2.

Japanese name: Otsubu-riburaria (Umezaki 1955 a).

Var. **hemisphaerica** (Kuetzing) Bornet & Flahault, l. c. 1886.

Plants hemispherical, solitary or occasionally confluent, up to 4–5 mm. in diameter.

Var. **confluens** Bornet, Mém. Soc. Nat. Sci. Nat. Math. de Cherbourg 28: 189, 1892.

Plants flattened and confluent, up to 5 cm. in diameter.

Habitat: Growing on rocks or pebbles in the upper littoral belt, or sometimes in the supralittoral belt, rarely epiphytic on larger algae (Ulva, Gloiopeltis, Bostrychia, and Rhodomela).

Amami Islands: Koniya, O-shima, *1776*, *1793*, *1838 c*, 10-11 Apr. 1955. Tean near Koniya, O-shima, *2239*, *2241*, 28 Jun. 1958. Ushuku, Kasari-mura, O-shima, *2431*, *2443*, *2534*, 10 Jul. 1958. Ikeji, Kikai-jima, *2382*, 6 Jul. 1958. So-machi, Kikai-jima, *2401*, 7 Jul. 1958.

Kyushu: Ushinohama, Kagoshima Pref., *2037*, 25 May 1956. Tomioka, Amakusa, *2009 a*, 23 May 1956. Shingu, Fukuoka Pref., *1977*, 20 May 1956. Tsuyasaki, Fukuoka Pref., *1985*, 21 May 1956.

Shimonoseki: Yoshimi, *256*, *275*, *285*, *290 b*, 5 Nov. 1950,

Seto Inland Sea: Shibukawa, Tamano, Okayama Pref., *1496 c*, 22 Jun. 1954. *1656*, 8 Feb. 1955. Ozuchi-jima off Tamano, Okayama Pref., *1518 a*, 23 Jun. 1954. *1592*, *1596*, 29 Sept. 1954. *1899 a*, *1912 a*, 5 Aug. 1955. Hon-jima, Shiaku Islands, *1552 c*, *1553 a*, *1554 a*, *1556 a*, *1558 b*, *1561 a*, *1564 b*, *1575 a*, 24 Jun. 1954. *1608*, *1614*, *1617*, 29 Sept. 1954. *1630 c*, *1661*, *1662*, *1670*, 8-9 Feb. 1955. *1917*, *1923 b*, *1925 b*, *1948 a*, 5 Aug. 1955. Tadano-umi, Hiroshima Pref., *299*, *306*, *308*, 8 Nov. 1950.

Awajishima: Yura, *1392*, 13 Jun. 1954.

Kii Peninsula: Kata, *634 b*, *635*, *636 a*, 27 Mar. 1952. Seto, Shirahama, *449*, *460 b*, 3 Aug. 1951. *529*, *538*, 2 Nov. 1951. *641*, *644*, 29 Mar. 1952. *573 b*, 30 Jan. 1952. Kashima, Tanabe Bay, *454*, 2 Aug. 1951. Hatake-jima, Tanabe Bay, *457*, *469*, 2 Aug. 1951.

Shima Peninsula: Wagu, *719*, 9 Jun. 1952. *798 a*, 4 Oct. 1952. O-shima off Wagu, *626*, 12

Mar. 1952. *828 a*, 5 Oct. 1952. Goza, *591*, 11 Mar. 1952.

Aichi Pref.: Himaga-jima, Atsumi Bay, *343 c*, K. Inagaki, 21 Jul. 1953.

Mi-ura Peninsula: Aburatsubo, *1008*, 29 Mar. 1953.

Boso Peninsula: Kominato, *1070 c*, 3 Apr. 1953. Futomi, *1096*, 4 Apr. 1953.

Amino: Amimo Bay, Kyoto Pref., *904 a*, 28 Oct. 1952.

Wakasa Bay: Kanmuri-jima off Maizuru Bay, *2116*, 10 Oct. 1956. Koiso, Maizuru Bay, *144 c*, 7 Apr. 1950. Takahama, Fukui Pref., *76*, 26 Sept. 1949. *102*, 22 Nov. 1949. *311 a*, 17 Nov. 1950. *344 b*, *350*, 31 Jan. 1951. *1588*, 1 Sept. 1954. Kato, Obama Bay, *52 b*, *53*, *54*, 8 Sept. 1949. *139*, *140*, 20 Mar. 1950. *153*, 6 May 1950. *357*, 1 Feb. 1951. *946 c*, 25 Jan. 1953. *971 a*, 15 Mar. 1953. Obama, Obama Bay, *240*, *242*, 14 Oct. 1952. Tagarasu near Obama, *122*, 23 Dec. 1949.

Aomori Pref.: Asamushi near Aomori, *1195 a*, *1197*, *1199*, 9 Jul. 1953. Ishizuki, Hiradate-mura, Higashitsugaru-gun, *1248*, K. Inagaki, 14 Jul. 1953.

Hokkaido: Muroran, *336*, 31 Aug. 1947. *560*, K. Inagaki, 25 Jan. 1951. *2139*, 15 Jul. 1953. Cape Shakotan, *335*, K. Iwamoto, 10 Jun. 1947. Oshoro, *1255 c*, 17 Jul. 1953 (as *Rivularia mamillata* by Umezaki, 1956 a). Hariusu near Otaru, *338*, 1 Jun. 1947. Lake Saroma, *339 b*, K. Iwamoto, Aug. 1947.

Rivularia atra, a cosmopolitan species, is commonly distributed on our coasts, from the Amami Islands to Hokkaido Island, growing on rocks or on other marine algae in the upper littoral belt or sometimes in the supralittoral belt, occurring throughout the year. The plants grow sometimes in solitary fashion (var. *hemisphaerica*) or rarely as confluent masses (var. *confluens*).

Rivularia opaca, which was described by Harvey (1859), was listed among the species inquirendae by Bornet & Flahault (1886) in their revision of Nostochineae; but, afterward, it was referred to *R. atra* by de Toni (1895). Moreover, a specimen of Rivularia from Japan, which had been deposited in Grunow's herbarium (labelled as collected by Y. Tanaka), was examined by Bornet & Flahault (1886) and it was identified as *R. atra*.

Womersley (1946) described the trichomes of Australian specimens as a little thicker than those of Northern Hemisphere specimens, as being 5–6.2μ; but the measurements in the Japanese specimens are almost the same as these, being 4–6μ. According to Bornet & Flahault (1886) they measure 2.5–5μ. In Australian specimens the lower sheaths are also very thick and sometimes diffluent. The lower cells are very long, 7.5–18μ, rarely 33μ in length or 3–6 (rarely 11) times as long as the diameter. Womersley also described such long cells in Australian specimens as 3–6 times as long as the diameter.

Rivularia mamillata Setch. & Gardn. is probably a young plant of *R. atra* rather than of *R. nitida* to which Gardner (1918) says it is nearest. Therefore, I have decided to refer the specimen, which was named *R. mamillata* in my previous paper (1956 a), to *R. atra*.

Geographical distribution: Cosmopolitan (on rocks and larger algae in marine and brackish waters).

General Part

1. Geographical distribution in the world

As will be mentioned in the next section, the bulk of aquatic Cyanophyta, with some exceptions, are cosmopolitan or widespread in their distribution; and even within a species the habitat varies, the plants occasionally occurring in marine or brackish waters, and in fresh or thermal waters. Therefore, no distinct local types of their geographical distribution in the marine waters of the world have been found. Moreover, the floristics of the marine blue-green algae in the world have been not yet so exhaustively studied as the other marine algae in which more detailed data on the geographical distribution have been published.

Before everything else, I have made a comparison of marine Cyanophycean flora of the Japanese Region (from Hokkaido Island to the Amami Islands, not Okamura's Japanese Region in 1932) with those of other regions of the world. The regions here studied are as follows: 1, the Southern Asia Region, including the Malay Archipelago, the East Indies, the Philippines, and the Chinese coast; 2, the Warmer Pacific Region, including the Hawaiian Islands and the southern islands of Polynesia, Micronesia, and Melanesia; 3, the Australia Region, including Tasmania and New Zealand; 4, the Pacific Coast of North America Region, from Alaska to Panama in Central America; 5, the Atlantic Coast of North America Region, including Florida and the coast of Gulf of Mexico; 6, the Atlantic Coast of Europe Region, including the Baltic Sea and British Isles; 7, the Mediterranean Region, including the the Baham Islands and the Greater and Lesser Antilles; 9, the Atlantic Ocean Region, including the Canary Islands, Iceland and the Faeröes Islands; and 10, the Indian Ocean Region, including Ceylon and Madagascar island. South America, Africa, and other regions in which floristic study is very poor are not included in this treatment. On the contrary, the Atlantic coast of Europe, the Mediterranean, and the Atlantic and Pacific coasts of North America floristically have been well and precisely explored, and the four regions have many species common to the Japanese Region: 52–64 species (60.8–74.4%) of the entire flora. This does not mean, however, that the floristic type of each of these regions is the same as that of the Japanese Region so that more than 75% of the species common to the four regions are widespread species in their distribution. The Australia Region, which has been poorly studied floristically, has only 25 species (22.9%) common to the Japanese Region. Of the Japanese species, 42 (48.8%) are common to the Southern Asia Region which is geographically in the tropical zone; and 54 (62.7%) are common to the Warmer Pacific Region which is geographically in the subtropical and tropical zones. 39 species or 45.3% of the total number of the Japanes species are known from the Indian Ocean Region. The West Indies Region, which is geographically in the subtropical zone, has 49 species (56.9%) which occur in the Japanese flora. 48 species (55.8%) of the total number of species of Japan are common to the Atlantic Ocean

O. laetevirens	...	+	...	+	+	+	+	...	+	+	+	...	+	...	+	...	...
O. amphibia	...	...	...	...	+	+	...	...	+	...	+	...	...	+	...	+	+
Skujaella Hildebrandtii	...	+	...	+	...	+	...	...	...	+	...	+	...	...	+	...	...
S. Thiebautii	...	...	...	+	...	+	+	...	...	+	...	+	+	+	+	...	...
Nostocaceae																	
Richelia intracellularis	...	...	...	+	...	...	+	...	...	...	+	...	...	...	+	...	...
Nostoc commune	...	...	+	...	...	+	+	...	+	+	+	...	+	+	...	+	+
Nodularia Harveyana	..	+	...	+	...	...	...	...	+	+	+	...	...	+	...	+	+
Hormothamnion enteromorphoides	...	...	+	...	...	+	+	...	+	+	...	...	+	+	+	...	..
Stigonemataceae																	
Mastigocoleus testarum	+	+	+	+	...	+	+	...	+	+	+	+	+	+	+	+	...
Brachytrichia Quoyi	+	+	+	+	...	+	+	+	+	+	+	+	+	+	+	+	...
Kyrtuthrix maculans	+	+	+	+	+	+	+	...	...	...	...	+	...	+	+	...	...
Scytonemataceae																	
Scytonema polycystum	...	...	+	...	...	+	+	...	...	...	...	...	...	...	...	...	...
Fremyella grisea	...	+	+	+	+	...	...	...	...	+	+	+	...	...	...	+	...
F. vitiensis	...	...	+	...	...	+	+	...	+	...	...	...	+	+	...	...	...
Rivulariaceae																	
Calothrix codicola	...	+	+	+	...	...	...	...	+	...	...	...	...	...	...	...	...
C. parasitica	+	+	+	+	+	...	...	...	+	+	+	+	...	+	...	+	...
C. scopulorum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	...
C. confervicola	...	+	+	+	+	+	+	+	+	+	+	+	+	+	...	+	...
C. crustacea	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	...
C. pilosa	...	+	+	+	...	+	+	+	+	...	+	+	+	...	+	+	...
Gardnerula corymbosa	...	+	+	...	...	+	+	...	...	+	...	+	+	+	...	...	...
Isactis plana	+	+	+	+	+	...	...	+	+	+	+	+	...	+	..	+	...
Rivularia polyotis	...	...	+	...	...	...	+	+	...	+	+	+	+	+	...	+	...
R. nitida	...	+	...	+	+	...	...	+	+	+	+	+	+	+	...	+	...
R. atra	+	+	+	+	+	...	+	+	+	+	+	...	...	+	...	+	...
Total	23	65	63	61	29	42	54	25	54	52	64	58	49	48	39	49	22
Percentage	26.6	75.5	73.2	70.9	33.7	48.8	62.7	22.9	62.7	60.8	74.4	67.4	56.9	55.8	45.3	56.9	25.5

Region which occupies geographically the tropical, subtropical, temperate, and subarctic zones.

It is clear from the above data that at present generalizations can not be made as to types of geographical distribution of species in the above mentioned regions, because probably of the poor and incomplete data of floras and because of the numerous species of widespread distribution which comprise so large a percentage of the total number in these floras.

2. Local distribution on the Japanese coast

Most of the species on the Japanese coast, except two new species and some species which are confined to tropical or subtropical regions, are cosmopolitan or widespread species; of these 49 (56.9% of the total number) are cosmopolian or subcosmopolitan, and the remaining species are by no means endemic. From that reason there do not seem to be distinct differences in distribution of species, as with the higher marine algae, among geographical regions. Moreover, the collection of specimens to date has by no means been sufficiently exhaustive to explain these matters completely, though a few locations have been well explored.

K. Okamura (1926, 31) analysized, from the point of view of geographical distribution, the floristic composition of the larger marine (green, brown, and red) algae of Japan and divided the Japanese marine waters, including the Kuriles, Ryukyu, Formosa and Bonin Islands, and excluding Saghalien, into five floristic regions, each of which is characterized by the presence of endemic or peculiar species: I, from Shumushu Island of the Kuriles through the Pacific coast of Hokkaido and the Sanriku coast of Iwate Prefecture to Kinkazan Island, Miyagi Prefecture; II, from Kinkazan Island, through the Pacific coast of Honshu, Shikoku, and the east coast of Kyushu, to Oshima Island, Miyazaki Prefecture, southern Kyushu; III, from the southern coast of Kyushu to Formosa, including the Bonin Islands and Ryukyu; IV, from Nomazaki, Kagoshima Prefecture, southern Kyushu, through the western and northern coasts of Kyushu and the Japan Sea coast of Honshu, to Tsugaru Strait between Honshu and Hokkaido; and V, from Tsugaru Strait, through the Japan Sea coast of Hokkaido, Soya Strait between Hokkaido and Saghalien and the Okhotsk coast of Hokkaido, to Cape Nosappu of Nemuro, the eastern end of Hokkaido. The floristic composition in region, Okamura pointed out, is chiefly due to the influence of ocean currents washing around the Japanese Islands.

First of all, I have tried to investigate the regional distribution of the Japanese species of blue-green algae according to a modification of Okamura's classification of the Japanese marine waters. I have designated the regions by the following names: I, the Northern Pacific Coastal Region, excluding the Kuriles; II, the Central Pacific Coastal Region, including the Seto Inland Sea; III, the Southwestern Islands Region, including the Tokara and Amami Islands, but excluding Ryukyu, Formosa and Bonin Islands; IV, the Japan Sea Coastal Region, including Mutsu Bay of Aomori Prefec-

ture; and V, the Northwest Hokkaido Coastal Region, including Rishiri and Rebun islands and Lake Saroma.

S. Segawa (1956) divided, from a geographical rather than from a floristic standpoint, the Japanese coast into 14 small regions. So far as the floristic study of Cyanophyta is concerned, however, Segawa's division is so detailed that it has not seemed useful here.

I, **the Northern Pacific Coastal Region:** The coast of this region, which is washed by the Oyashio Current of cold water running from the Kurile Islands, is floristically poor, with only 23 species or 26.6% of the total number of Japanese species listed. *Brachytrichia Quoyi*, common in tropical and subtrogical regions, is found rarely at Muroran, which seems to be the northernmost locality for this specis in Japan as well as in the Pacific Ocean, although on the Atlantic coasts of Europe and North America of the same latitude as Muroran it grows. On the other hand, this region is rich in endemic species of larger algae such as Thalassiophyllum, Constantinea, Arthrothamnion, Odonthalia, Laminaria, and Fucus, according to Okamura.

II, **the Central Pacific Coastal Region:** The entire coastal line is washed by the Kuroshio Current. Among five regions this is richest in number of species, with 65 species (75.5% of the total number), including 41 (47.6%) widespread species. Species peculiar to this region are *Microcoleus Wuitneri*, *M. sanctae-crucis*, *Symploca atlantica*, *Phormidium Feldmannii*, and *P. submembranaceum*, which may be found in other regions during further exploration. All of the species of Oscillatoriaceae excepting *Plectonema Nostocorum*, *Phormidium molle*, *P. Ectocarpii*, *Oscillatoria brevis*, and *O. amphibia*, all of the species of Stigonemataceae, and all of the species of Rivulariaceae excepting *Rivularia polyotis* are found in this region. *Gardnerula corymbosa*, a tropical alga, is found at Shirahama, Kii Peninsula, which seems to be the northernmost station for the species in the Pacific Ocean. Until now, the Hawaiian Islands, as far as I know, were the northern limits for this species in the Pacific Ocean. In Shirahama the plants are rare in occurrence and dwarf in size, while on the Amami Islands in the Southwestern Islands Region they are very luxuriant in occurrence and size. According to Okamura this region is rich in temperate flora.

III, **the Southwestern Islands Region:** Of the 63 species present, 7 tropical and subtropical species were found to be confined to this region. They are as follows: *Phormidium Crosbyanum*, *P. penicillatum*, *Fremyella vitiensis*, *Gardnerula corymbosa*, *Rivularia polyotis*, *Scytonema polycystum*, and *Hormothamnion enteromorphoides*. The larger marine algae in this region are chiefly subtropical, according to Okamura. Concerning the marine blue-green algae, although most of the species (40 or 46.5% of the total number) are widespread, the floristic type to which they belong may be said to a certain extent to be subtropical, because of the presence of the tropical and subtropical species.

IV, **the Japan Sea Coastal Region:** The western coast of Kyushu faces the East China Sea, and the northern coasts of Kyushu and Honshu face the Japan Sea. The Tsushima Current, a branch of the Kuroshio Current, flows from south to north along these coasts, and it reaches through the western side of Hokkaido and Soya Strait to the Okhotsk Sea. 61 species (70.9% of the total number), the majority of which were found in Wakasa and Amino Bays, are included in this region. *Agmenellum quadruplicatum*, *Phormidium molle*, *P. Ectocarpii*, *Oscillatoria brevis*, and *Richelia intracellularis*, though not endemic, are found confined to this region. *Richelia intracellularis* is rather of warmer water origin and seems to be common to the Pacific Coastal Region, because Okamura (1916) described it as occurring off Boso Peninsula.

V, **the Northwest Hokkaido Region:** This is the northernmost region of the Japanese coast, washed by the slow stream of the Tsushima Current. *Oscillatoria amphibia* is a species which was found only in this region. As compared with the Northern Pacific Coastal Region, this is a little richer floristically, probably because of the influence of the Tsushima Current. *Agmenellum thermale*, *Hydrocoleum cantharidosmum*, *Microcoleus tenerrimus*, *Lyngbya Rivulariarum*, *L. semiplena*, *Spirulina subsalsa*, *S. labyrinthiformis*, *Oscillatoria laetevirens*, *O. amphibia*, *Fremyella grisea*, *Calothrix confervicola*, and *Rivularia nitida*, which have not been found in the North Pacific Coastal Region, are known in this region.

It has been learned from this study that, when the blue-green algal floras are compared with each other from the point of view of latitude, the northern and colder regions are poorer in number of species than the southern and warmer regions, although there is little distinct difference in the floristic composition of the regions. I have reached the conclusion that the Japanese marine Cyanophycean flora may be divided in two regions, namely: the Southwestern Islands Region, consisting mainly of the Tokara and Amami Islands, and the Honshu Region, including Kyushu, Shikoku, and Hokkaido islands. The flora of the former region is subtropical and the latter temperate or subtemperate.

3. Ecology

Diverse habitats are occupied by the species collected, some species being found growing on rocks, some epiphytic on larger algae, some endophytic in other algae, some planktonic in the sea or floating free among filamentous algae, and others perforating mollusk shells or corals. According to the kind of habitat and substratum I have classified them into five kinds, namely: a, lithophytic form; b, epiphytic form; c, endophytic form; d, planktonic form; and e, shell-perforating form. The following are brief ecological observations on each form.

a). **Lithophytic form:** Most of the marine Cyanophyta grow on rocks, chiefly in the littoral belt; and they often play an important role in the colouration of rocks, sometimes the whole surfaces of rocks being coloured blue-green or other colours because of the conspicuous growth of the algae. They grow not only horizontally

but also vertically on rocks, although they are not so conspicuous as in the larger marine algae. In classifying the vertical distribution of algal vegetation, various schemes and terms have been proposed by many ecologists. The terms here adopted, however, are those of Feldmann (1951), who applied them on the Mediterranean coast. The term lower infralittoral belt has not been used in this study, for all the present specimens have been found and collected on shores between the supralittoral and upper infralittoral belts. The littoral belt between high tide and low tide is subdivided into three horizones, upper, middle and lower, according to Feldmann; but in this paper the belt is divided into roughly two, upper and lower, for on the Japanese coast the intertidal belt is narrow, without noticeable tides. This classification is applicable only to the coasts of the Pacific and of the Seto Inland Sea and to the western coast of Kyushu, where the belt between high and low tide levels is comparatively broad, ranging from 2 m. to 5 m. On the Pacific coast of Honshu it is 2 m.; and on the coast of Seto Inland Sea it is 3–4 m. On the other hand, on the Japan Sea coast there is no proper littoral belt, being only 30 cm. even at the time of lowest tide; therefore I have not attempted to subdivide the littoral belt of the Japan Sea coast.

Supralittoral belt: The supralittoral belt here is regarded as that part of the shore up to 2 m. or 2.5 m. above high tide level, so that the lichen zones in the upper part of the belt are not included. *Entophysalis deusta*, *Calothrix scopulorum*, *C. pilosa*, and *Plectonema calothrichoides* are conspicuous in the supralittoral belt. Among them the strata of *Calothrix scopulorum* are most conspicuous, especially at the uppermost level, forming widely expanded, dark blue-green girdles. Sometimes these girdles consist of mixtures with *Entophysalis deusta*, *Lyngbya lutea*, *L. semiplena*, *Plectonema calothrichoides*, and *Microcoleus chthonoplastes*. At Nagahama, Maizuru Bay, girdles of *Entophysalis deusta* 20–30 cm. wide have been found in winter seasons, but they disappear in the spring. In many cases, girdles of *Calothrix scopulorum* are followed by girdles of *Calothrix pilosa*, and a few small masses of *Microcoleus chthonoplastes* and *Oscillatoria nigro-viridis* occasionally appear here and there. On Kyushu and the Amami Islands, *Oscillatoria nigro-viridis–Bostrychia tenella* girdles have been found in the uppermost part of the supralittoral belt, though *O. nigro-viridis* grows generally on shaded rocks in the upper littoral at other stations. In the warmer waters of Japan, *Bostrychia tenella* is a conspicuous species in the supralittoral belt. *Lyngbya semiplena* and *L. confervoides* have sometimes been found growing in rock depressions filled with marine water from heavy seas and at other seasons becoming nearly fresh with rain water. Although these algae grow above the littoral belt, according to Utinomi's (1950) ecological classification they belong to a hydrophilic epibiont, for they grow on rocks the surfaces of which are always immersed in marine water even at ebb tide. On the contrary, both *Calothrix pilosa* and *C. scopulorum* belong to a xerophilic epibiont, for they grow always on rocks which periodically become dried. On Rishiri and Rebun

islands of Hokkaido *Calothrix scopulorum* has been found growing in the lower part of the supralittoral belt or near high tide level, never in the uppermost part of the shore as seen on the coasts of Honshu and southern islands. Algae which grow in the supralittoral belt are always more exposed to changing weather conditions than those under water; moreover, they are exposed also to changes in salinity and sunlight. Thereby, it seems that they have more adaptability to environments than those growing in other belts.

Littoral belt: The littoral belt, especially the upper littoral, is rich in number of species; and it is probable that there grow the majority of lithophytic species. On the Japan Sea coast most of lithophytic species, except a few species of the supralittoral belt, occur on rocks in the narrow littoral belt. In the Seto Inland Sea, the uppermost inhabitants of the upper littoral are usually *Microcoleus chthonoplastes* and *M. tenerrimus* which form wide girdles, sometimes more than 2 m. broad. The upper limit of the girdle sometimes penetrates into the supralittoral belt or into the lower part of the strata of *Calothrix pilosa*, and the lower limit sometimes extends to the zones of *Brachytrichia Quoyi*, *Rivularia atra*, and *Isactis plana*. On the coast facing the open sea, for instance, on O-shima, Shima Peninsula, the surfaces of the rocks in the upper littoral are sometimes covered with bright blue-green strata of *Calothrix crustacea* or the gelatinous strata of *Hydrocoleum lyngbyaceum*.

Upper infralittoral belt: In the upper infralittoral belt, which means here a depth of 2 m. below low tide level, the algal vegetation decreases rapidly and is very poor as compared with other belts. Only a few species have been found: On the Amami Islands *Hormothamnion enteromorphoides* and *Lyngbya majuscula*; in the Seto Inland Sea *Symploca hydnoides*, which generally grows in the lower littoral belt; and on Shima Peninsula, *Hydrocoleum glutinosum* and *Spirulina subsalsa*.

It is evident from this study that the upper littoral belt is richest in number of species and in vegetation, whereas the upper infralittoral belt is poorest; the marine blue-green algae grow best on rocks in shallow water and are adapted to direct or strong sunlight.

b). **Epiphytic form:** Many species have been found growing on the larger marine algae or sometimes even on other filamentous Cyanophyta; above all, Cladophora, Chaetomorpha, Codium, Myelophycus, Sargassum, Gelidium, Lyngbya, and Calothrix are favorable hosts for epiphytic plants. The following are conspicuous epiphytic species: *Entophysalis conferta*, *Calothrix confervicola*, *Fremyella grisea*, *F. vitiensis*, *Phormidium Feldmannii*, *Lyngbya Nordgaardii*, *L. gracilis*, *L. baculum*, *L. sordida*, *L. epiphytica*, and *L. infixa*. *Calothrix crustacea*, *Isactis plana*, *Rivularia atra*, *Spirulina tenerrima*, *Oscillatoria nigro-viridis*, *O. Corallinae*, *Lyngbya semiplena*, *Symploca hydnoides*, and *Hydrocoleum lyngbyaceum*, which are usually lithophytic, have also been found epiphytic on other algae.

c). **Endophytic form:** Several species, smaller than most epiphytic plants, have been found growing in other algae, mostly in gelatinous algae, without any

conceivable harm to the host. Unlike epiphytic plants, most of endophytic species seem to be selective as to their hosts, for instance: *Calothrix parasitica* grows mainly in *Nemalion vermiculare*, *N. multifidum*, and *N. pulvinatum*; *Lyngbya Rivularium* in *Rivularia polyotis*, *Brachytrichia Quoyi*, and in the sheaths of *Hydrocoleum cantharidosmun*, *H. glutinosum*, and *H. lyngbyaceum*; *Calothrix codicola*, *Microcoleus Wuitneri*, *M, Voukii*, *Hydrocoleum confluens*, and *H. coccineum* in *Codium fragile*, *C. divaricatum*, and *C. adhaerens*. The relationship between an endophyte and its host is an interesting problem both ecologically and physiologically. Plants of *Brachytrichia Quoyi* in Codium seem to have originated from lithophytic plants; they probably result from the growth of hormogones liberated from lithophytic plants. Examples of lithophytic algae becoming endophytic in other algae are by no means rare. Japanese plants of *Hydrocoleum confluens* all have been found in Codium, whereas the type specimen of *Microcoleus confluens* Setch. & Gardn. is lithophytic. *Richelia intracellularis* which grows in the cells of *Rhizosolenia styliformis* is a species peculiarly endophytic; it is generally described as a symbiotic species, although its relationship to the host species is not true symbiosis.

d). **Planktonic form:** Although not so numerous as the freshwater species, some marine species are planktonic, generally abundant in warmer seas. Only two species which occur in the ocean or open sea are found in the Japanese region: *Skujaella Hildebrandtii* and *S. Thiebautii*, both of which have been found producing red water. Red water or red tide in the sea is sometimes produced by the explosive multiplication of the trichomes of these species. Other plankton species have been found floating in small tide pools or rock depressions filled with marine water near high tide level or in the supralittoral belt, and floating freely among filamentous algae such as Cladophora, Bryopsis, Sphacelaria, Ectocarpus, Corallina, Calothrix, and Hydrocoleum. *Coccochloris stagnina*, *Agmenellum quadruplicatum*, *A. thermale*, *Anacystis dimidiata*, *Gomphosphaeria aponina*, *Johannesbaptistia pellucida*, *Oscillatoria Bonnemaisonii*, and *O. chalybea* were found among other filamentous algae in rock pools or rock depressions.

e). **Shell-perforating form:** In living and dead mollusk shells, corals, and calcareous algae some blue-green algae are sometimes found growing. Because of the growth of these species, sometimes in association with perforating species of Chlorophyta, *Gomontia polyrhiza* and *Ostreobium Queketti*, the shells or corals are coloured blue-green. Species of the shell-perforating blue-green algae which have been found on the Japanese coast are only three, *Entophysalis deusta*, *Mastigocoleus testarum*, and *Plectonema terebrans*, of which *Mastigocoleus testarum* is most commonly encountered. On the Japanese coast there are no conspicuous calcareous rocks as seen in the Mediterranean Sea and British Isles where many shell-perforating blue-green species are widely discovered. On the Japanese coast the three species are widely distributed, but they have not yet been found within the shells of freshwater mollusks.

4. Seasonal periodicity

No one made a study on the seasonal periodicity of the marine blue-green algae, except in connection with such studies on the larger marine algae. On the contrary, the freshwater blue-green algae, in many cases together with other freshwater algae, have been studied rather carefully; and it has been shown that their growth is seasonal. That the seasonal periodicity of the marine blue-green algae, with the exception of some species, is not so conspicuous has been observed in this study.

Lindstedt (1943) reported that on the western coast of Sweden the blue-green algae occur throughout the year and that during the summer and autumn their growth is especially luxuriant and abundant. Among the Japanese marine blue-green algae an agreement with Lindstedt's observation is seen to a certain extent.

I observed periodically the marine blue-green algae in Amino Bay, Kyoto Prefecture, from September 1952 to October 1953 except in May and July 1953; and I have noted that frequency of algal occurrence is greatest in the months of August, September, and October (or summer and early autumn), and that in the winter season (December, January, and February) in general these algae are rare or sparse, although here and there certain species were plentiful. Plankton species (*Coccochloris stagnina* and *Gomphosphaeria aponina*) in rock pools in which the water was heated by the sun, occurred from August to October. Species endophytic in Codium (*Calothrix codicola* and *Brachytrichia Quoyi*) were found in February when the water was coldest of the year. During the winter season were found *Entophysalis conferta, Calothrix scopulorum, C. pilosa, C. codicola,* an endophytic form of *Brachytrichia Quoyi, Lyngbya semiplena, Plectonema norvegicum,* and *P. calothrichoides. Entophysalis conferta* was found throughout the year, growing on various algae, in one or another of its various growth forms.

Also, I have made an analysis of the seasonal occurrence on all of the species collected during the 13 years from 1948 to 1960 in Wakasa Bay; and I have discovered that the general phenomenon of the algal occurrence due to season is quite similar to that of Amino Bay. *Entophysalis conferta, E. deusta, Calothrix scopulorum, C. crustacea, Isactis plana, Rivularia atra, Kyrtuthrix maculans, Lyngbya lutea, L. semiplena,* and *Hydrocoleum lyngbyaceum,* all cosmopolitan or subcosmopolitan species, were found occurring throughout the year. *Calothrix parasitica* was found from June to August when Nemalion plant was growing. Species endophytic in Codium (*Calothrix codicola, Brachytrichia Quoyi, Microcoleus Voukii,* and *Hydrocoleum confluens*) were found in winter and spring seasons when Codium plants, which are perenial, were matured. *Richelia intracellularis* occurred in August in Amino Bay and in October in Wakasa Bay. In Wakasa Bay, *Brachytrichia Quoyi* begins its growth at the beginning of winter or early January, and then in the summer season or from June to August the plants mature, becoming as large as 1–2 cm. in diameter. In

Amino Bay, the matured plants were collected in August. In Shirahama, Kii Peninsula, the plants appear at the beginning of November, and in mid-April become cavernous and form hormogones in the erect filaments. In May the well matured plants are found plentifully, but in July and August most of them are decayed although growing rarely on shaded rocks or near low tide level. In the Seto Inland Sea, the period from June to August is the best time for the growth of this alga. On the Amami Islands, June was the best time for the alga. On the contrary, at northern stations such as Hokkaido and Matsushima Bay, where the alga is rare in occurrence, July is the season for the alga. As compared with many other species the growing season of *B. Quoyi* seems to be more or less regular, and it has been noted that the best growth is in the summer season or in months of high temperature of the water.

Kyrtuthrix maculans grows throughout the year, but its luxuriant growth is seen in spring and summer seasons. *Gardnerula corymbosa*, which is distributed in tropical and subtropical regions, was collected in April, June, and July on the Amami Islands, while at Shirahama, Kii Peninsula, it was found in November. *Skuyaella Hildebrandtii*, a tropical plankton species, was collected only in the summer seasons of 1955 and 1956 in Tanabe Bay, Kii Peninsula, and in July in 1955, in the sea between Goto and Danjyo Islands, off Nagasaki, Kyushu.

Generally speaking, cosmopolitan or subcosmopolitan species are not comparably affected by the environmental conditions; they grow without respect to seasons, although various growth forms may be influenced by the seasons. *Calothrix scopulorum* occurs throughout the year, but its luxuriant growth is seen in the winter season.

5. Economy

Marine Cyanophyta have not had much economic importance for the Japanese. The marine algae of other divisions, on the other hand, have been utilized by our countrymen as foods, manures, medicines, industrial materials, and for many other uses. Recently, attention has been turned to some freshwater species of the blue-green algae which fix nitrogen, and these can be employed as manures in paddy field. The marine species are most important in their relations with fisheries.

Relations with fisheries: According to Okamura (1922), *Mastigocoleus testarum*, which is well known as a shell-perforating species, rapidly spreads in fishing farms in Ago Bay, and pearl-oyster shells for pearl culture were badly damaged by its growth. In Ago Bay and other pearl culture farms, so far as I know, such death of the oysters has not occurred. It is said that at the present time the cause of death of pearl-oysters is in many cases due to the explosive growth of plankton algae such as Gymnodinium which are called red water or red tide. Dead or old shells rather than living or young shells of mollusks (not pearl-oyster shells) are generally affected by the growth of *Mastigocoleus testarum*, in many cases in associa-

tion with other perforating species such as *Plectonema terębrans* and *Entophysalis deusta*, or sometimes with Chlorophycean species such as Gomontia and Ostreobium; and the shells become coloured blue-green.

Oceanic planktonts such as *Skujaella Thiebautii* and *S. Hildebrandtii* do sometimes rapidly multiply in the fishing waters of the sea and play an important role in the production of red water. For the first time, in 1907, Okamura reported the red water produced by Skujaella (*Trichodesmium erythraeum*) off the coast of Tosa (Kochi Pref., Shikoku), adding that the water was of a dark reddish colour. Relations between red water and fishing have been reported by many students of fisheries. T. Tsujita (1956) found the explosive multiplications of *Skujaella Hildebrandtii* (as *Trichodesmium* sp. by him) and *Skujaella erythraea* (as *Trichodesmium erythraeum* by him) in the fishing area off the western coast of Kyushu, and he said that the water in the place was of a "white colour" instead of a red.

Uses as food: Marine blue-green algae have never been used as food materials in Japan. Some freshwater species, however, have been available as cooking materials for soups since ancient time, namely: *Aphanothece sacrum* (Japanese name: Suizenji-nori), *Nostoc verrucosum* (popular name: Ashitsuki-nori), and *N. commune* (popular name: Kamogawa-nori, Kawatake, Kibune-nori, or Shirakawa-nori).

In Formosa, *Brachytrichia Quoyi*, which measures 5 cm. or more in size, is used as cooking materials or sweets, according to Okamura (1915, 36) and Fan (1953). The Japanese, however, have not eaten it as a food, probably because it is rare in occurrence on the Japanese coast and of a small size, generally measuring up to 1 cm. or to 2.5–(3) cm. at most.

Summary

1. I have studied from the floristic and systematic standpoint the blue-green algae which occur on the coast of Japan; also their ecology, their geographical distribution on the Japanese coast and in the world, and their economy have been dealt with.

2. In the floristic study 2 orders, 7 families, 32 genera, and 86 species have been recorded. Of them one genus, one species, and one form are new to scinece, and one species is transferred to other genus. The new genus is Sphaeronema (Oscillatoriaceae). The new species is *Oscillatoria Yonedae*. The new form is *Arthrospira miniata* f. *acutissima*. The new combination is *Sphaeronema lithophila* (Oscillatoriaceae). In the Oscillatoriaceae, *Spirulina attenuata* Umez. (1952) is placed as a synonym of *Oscillatoria Corallinae* (Kuetz.) Gom., *Microcoleus tenerrimus* var. *longus* Umez. (1952 a) as a synonym of *Microcoleus tenerrimus* Gom., *Hydrocoleum Boergesenii* Gardn. (1932) as a synonym of *Sirocoleum Kurzii* (Zeller) Gom., *Hydrocoleum codicola* Setch. & Gardn. (1924) as a synonym of *Hydrocoleum confluens* (Setch. & Gardn.) Dr., and *Arthrospira breviarticulata* Setch. & Gardn. (1918) as a synonym of *Oscillatoria mar-*

garitifera (Kuetz.) Gom. In the Rivulariaceae *Calothrix nidulans* Setch. & Gardn. (1924) is placed as a synonym of *C. parasitica* (Chauv.) Thur., *Calothrix nodulosa* Setch. & Gardn. (1924) as a synonym of *Calothrix confervicola* (Roth) Ag., and *Calothrix clausa* Setch. & Gardn. (1930), *C. rectangularis* Setch. & Gardn. (1918), and *C. aeruginea* Thur. (1875) as synonyms of *Calothrix crustacea* Thur.

3. The materials used to the present work have been collected from all the coasts of Japan, from the Amami Islands to Hokkaido Island, mostly by myself and partly by my friends and colleagues, during the fourteen years from 1947 to 1960.

4. The geographical distribution of the Japanese blue-green algae is not distinctly different from that of other regions of the world, probably because collections of these algae are neither numerous nor complete and the algae are mostly cosmopolitan or widespread in their distribution.

5. As to their local distribution on the Japanese coast, divided here into five regions, there have been noted no distinct differences in the floristic composition of these several regions. But the Japanese marine Cyanophycean flora may be divided in two regions, namely: The Southwestern Islands Region, mainly comprising the Amami and Tokara Islands, which is subtropical in flora; and the Honshu Region, including Kyushu, Shikoku and Hokkaido islands, which is temperate or subtemperate in flora.

6. According to the kind of habitat and substratum on which the algae grow, the specimens collected have been classified into five forms–a, lithophytic form; b, epiphytic form; c, endophytic form; d, planktonic form; and e, shell-perforating form, –and brief observations on each form have been described.

7. In some species a certain amount of seasonal periodicity has been found. The majority of the marine blue-green algae, generally cosmopolitan and subcosmopolitan species, are not equally affected by the environmental conditions, but according to species, they develop best in late summer or in the autumn.

8. The marine Cyanophyta have been of little economic importance to the Japanese as compared with the other marine and freshwater algae. Relations with fisheries seem to have caused the most comment: The destruction of pearl-oysters is said to be caused by the growth of the shell-perforating species, *Mastigocoleus testarum*. *Skujaella Hildebrandtii*, *S. Thiebautii*, and *S. erythraea* play an important role for the production of red waters in the seas. No species have been used as food as yet by the Japanese.

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Explanation of plates

Plate 1

Fig. 1. *Coccochloris stagnina* Spreng. Two plants. ×700.
Fig. 2. *Anacystis aeruginosa* (Zanard.) Dr. & Daily. Part of a plant. ×600.
Fig. 3. *Anacystis dimidiata* (Kuetz.) Dr. & Dailly. One, two, and four-celled plants. ×600.
Fig. 4. *Johannesbaptistia pellucida* (Dick.) Taylor & Dr. Two plants. ×500.
Fig. 5. *Agmenellum quadruplicatum* de Bréb. A plant. ×600.
Fig. 6. *Agmenellum thermale* (Kuetz.) Dr. & Daily. A plant. ×600.
Fig. 7. *Gomphosphaeria aponina* Kuetz. Two plants. ×600

Plate 2

Fig. 1. *Entophysalis deusta* (Menegh.) Dr. & Daily. a, group of plants. ×600. b, three plants. ×600.
Fig. 2. *Entophysalis conferta* (Kuetz.) Dr. & Daily. a, group of plants on a Cladophora, showing various stages of development. ×600. b, plants in the cortical layer of a Gloiopeltis. ×600.

Plate 3

Fig. 1. *Schizothrix lacustris* A. Braun. a, habit sketch of a plant. ×320. b, apex of a filament. ×1500.
Fig. 2. *Hydrocoleum confluens* (Setch. & Gardn.) Dr. a, habit sketch of a plant. ×100. b, apices of three filaments. ×700.
Fig. 3. *Hydrocoleum coccineum* Gom. a, habit sketch of a plant. ×50. b, apices of three trichomes. ×600.
Fig. 4. *Hydrocoleum lyngbyaceum* Kuetz. Apex of a plant. ×600.
Fig. 5. *Hydrocoleum glutinosum* (Ag.) Gom. Apex of a plant. ×550.

Plate 4

Fig. 1. *Hydrocoleum cantharidosmum* (Mont.) Gom. a, habit sketch of a plant. ×200. b, apex of a filament. ×500.
Fig. 2. *Sirocoleum Kurzii* (Zeller) Gom. a, habit sketch of a plant. ×40. b, apices of two trichomes. ×600.
Fig. 3. *Microcoleus Wuitneri* Frémy. a, habit sketch of a plant. ×150. b, apex of a trichome. ×1300.
Fig. 4. *Microcoleus Voukii* Frémy. a, habit sketch of a plant. ×150. b, apex of a trichome. ×1500.

Fig. 5. *Microcoleus sanctae-crucis* Frémy. a, habit sketch of an entire plant and apices of two plants. ×600. b, apices of two trichomes. ×2000.

Plate 5

Fig. 1. *Microcoleus tenerrimus* Gom. Apex of a plant. ×1500.
Fig. 2. *Microcoleus chthonoplastes* Thur. a, apex of a plant, ×500. b, apex of a trichome. ×1000.
Fig. 3. *Plectonema terebrans* Born. & Flah. A filament with two single-branchings. ×1500.
Fig. 4. *Plectonema Nostocorum* Born. a, habit sketch of plants. ×100. b, apex of a filament with a single-branching. ×1500.
Fig. 5. *Plectonema norvegicum* Gom. a, apex of a filament with a single-branching. ×1500. b, middle of a filament with a geminate-branching. ×1500.

Plate 6

Fig. 1. *Plectonema calothrichoides* Gom. a, habit sketch of plants. ×100. b, apex of a filament with a single-branching. ×1500.
Fig. 2. *Lyngbya epiphytica* Hieron. a, habit sketch of plants on a filament of *Calothrix crustacea*. ×500. b, three filaments on *Calothrix crustacea*. ×1500.
Fig. 3. *Lyngbya Nordgaardii* Wille. a, habit sketch of plants. ×100. b, apex of a filament. ×1500.
Fig. 4. *Lyngbya sordida* (Zanard.) Gom. Apex of a filament. ×500.
Fig. 5. *Lyngbya gracilis* (Menegh.) Rabenh. Apex of a filament. ×600.
Fig. 6. *Lyngbya baculum* Gom. Apices of two filaments. ×600.
Fig. 7. *Lyngbya pellucida* Umez. Three filaments. ×1000.

Plate 7

Fig. 1. *Lyngbya Rivulariarum* Gom. a, habit sketch of plants in a plant of *Brachytrichia Quoyi*. ×500. b, apex of a filament. ×1500.
Fig. 2. *Lyngbya infixa* Frémy. a, habit sketch of plants on an utricle of *Codium fragile*. ×100. b, apex of a filament. ×1000.
Fig. 3. *Lyngbya lutea* (Ag.) Gom. Apices of three filaments. ×600.
Fig. 4. *Lyngbya semiplena* (C. Ag.) J. Ag. a, habit sketch of plants. ×⅔. b, apices of two filaments. ×600.

Plate 8

Fig. 1. *Lyngbya aestuarii* (Mert.) Liebm. a, habit sketch of plants on *Corallina pilulifera*. ×⅔. b, f. *aeruginosa*. Apex of a filament. ×500. c, f. *spectabilis*. Apex of a filament and middle of a filament with a false-branching. ×500.
Fig. 2. *Lyngbya confervoides* C. Ag. a, habit sketch of plants. ×⅔. b, apex of a filament. ×600.
Fig. 3. *Lyngbya majuscula* Harv. a, habit sketch of plants. ×⅔. b, apex of a filament. ×600.

Plate 9

Fig. 1. *Symploca hydnoides* Kuetz. a, habits of plants showing five forms of plant. ×⅔. b, apices of three filaments. ×600.
Fig. 2. *Symploca atlantica* Gom. a, habit sketch of plants. ×⅔. b, apex of a filament. ×600.
Fig. 3. *Phormidium molle* (Kuetz.) Gom. Apex of a filament. ×1200.
Fig. 4. *Phormidium Ectocarpii* Gom. a, habit sketch of plants in a glass-vessel. ×½. b, apex and middle of a filament. ×2000.
Fig. 5. *Phormidium tenue* (Menegh.) Gom. Apices of two trichomes. ×600.
Fig. 6. *Phormidium corium* (Ag.) Gom. Apices of two filaments. ×600.

Plate 10

Fig. 1. *Phormidium Feldmannii* Frémy. Apices of two filaments. ×600.
Fig. 2. *Phormidium penicillatum* Gom. a, habit sketches showing two forms of plant. ×½. b, apices of two filaments. ×600.
Fig. 3. *Phormidium submembranaceum* (Ardiss. & Straff.) Gom. Apex of a trichome. ×600.
Fig. 4. *Phormidium Crosbyanum* Tild. a, apex of a filament. ×650. b, habit sketch of a plant. ×½.

Fig. 5. *Arthrospira miniata* (Hauck) Gom. f. *miniata*. Apices of two trichomes. ×600.
Fig. 6. *Arthrospira miniata* f. *acutissima* Umez. a, habit sketch of a plant. ×100. b, apex of a trichome. ×600.
Fig. 7. *Spirulina tenerrima* Kuetz. a, a trichome. ×500. b, apex of a trichome. ×1500.
Fig. 8. *Spirulina major* Kuetz. Middle of a trichome. ×1500.
Fig. 9. *Spirulina subsalsa* Oerst. Apex of a trichome. ×1500.
Fig. 10. *Spirulina labyrinthiformis* (Menegh.) Gom. A trichome. ×1500.
Fig. 11. *Sphaeronema lithophila* (Erceg.) Umez. a, a plant. ×150. b, two trichomes. ×1500.

Plate 11

Fig. 1. *Oscillatoria Bonnemaisonii* Crouan. Apex of a trichome. ×500.
Fig. 2. *Oscillatoria margaritifera* (Kuetz.) Gom. Apex of a trichome. ×500.
Fig. 3. *Oscillatoria chalybea* Mertens. Apex of a trichome. ×540.
Fig. 4. *Oscillatoria Yonedae* Umez. Apex of a trichome. ×600.
Fig. 5. *Oscillatoria nigro-viridis* Thwaites. Apices of two trichomes. ×700.
Fig. 6. *Oscillatoria Corallinae* (Kuetz.) Gom. Apex of a trichome. ×700.
Fig. 7. *Oscillatoria laetevirens* Crouan. Apex of a trichome. ×1300.
Fig. 8. *Oscillatoria brevis* Kuetz. Apex of a trichome. ×600.
Fig. 9. *Oscillatoria amphibia* Ag. Apices of two trichomes. ×1500.
Fig. 10. *Skujaella Hildebrandtii* (Gom.) J. de Toni. a, habit sketch of a plant. ×10. b, apices of two trichomes (right, the protoplasm is coagulated in the center of the cell). ×1200.
Fig. 11. *Skujaella Thiebautii* (Gom.) J. de Toni. a, habit sketches of two plants. ×10. b, apex of a trichome. ×1200.

Plate 12

Fig. 1. *Richelia intracellularis* Schmidt. a, habit sketch of plants in the cells of *Rhizosolenia styliformis*. ×100. b, two plants. ×700.
Fig. 2. *Nostoc commune* Vauch. a, a plant. ×1. b, vertical section of the peripheral part of a plant. ×600.
Fig. 3. *Nodularia Harveyana* Thur. A filament. ×600.
Fig. 4. *Hormothamnion enteromorphoides* Grunow. a, habit sketch of a plant. ×1. b, apices and middle of three filaments. ×600.
Fig. 5. *Mastigocoleus testarum* Lagerh. Three intricated filaments. ×600.

Plate 13

Brachytrichia Quoyi (Ag.) Born. & Flah. a, plants. ×1. b, vertical section of a plant. ×1. c, vertical section of a small part of a plant. ×700.

Plate 14

Fig. 1. *Kyrtuthrix maculans* (Gom.) Umez. a, habit sketch of plants on stone. ×1. b, vertical section of a small part of a plant. ×650.
Fig. 2. *Fremyella vitiensis* (Ask.) J. de Toni. Two filaments. ×600.

Plate 15

Fig. 1. *Scytonema polycystum* Born. & Flash. a, habit sketch of plants. ×1. b, a filament with a geminate-branching. ×500. c, a filament with a single-branching. ×500.
Fig. 2. *Fremyella grisea* (Thur.) J. de Toni. Four filaments on a Lyngbya. ×600.
Fig. 3. *Calothrix codicola* Setch. & Gardn. Group of filaments. ×600.

Plate 16

Fig. 1. *Calothrix parasitica* (Chauv.) Thur. Two filaments. ×600.
Fig. 2. *Calothrix confervicola* (Roth) Ag. Group of filaments. ×200.

Plate 17

Fig. 1. *Calothrix scopulorum* (Web. & Mohr) Ag. a, plants on stone. ×1. b, two filaments. ×600.
Fig. 2. *Calothrix crustacea* Thur. Group of filaments. ×200.

Plate 18

Fig. 1. *Calothrix crustacea* Thur. Group of filaments, slightly diagrammatic. ×50.

Fig. 2. *Calothrix pilosa* Harv. a, habit sketch of plants on rock. ×½. b, group of filaments, slightly diagrammatic. ×20. c, a young plant attaching to the side of an old plant. ×50. d, apices of two filaments. ×50. e, middle of a filament with a Scytonema-like branching. ×50.

Plate 19

Gardnerula corymbosa (Harv.) J. de Toni. a, habit sketches of plants showing various stages of development. ×3. b, a plant showing the arrangement of filaments. ×50. c, apex of a plant. ×450. d, base of a plant. ×450.

Plate 20

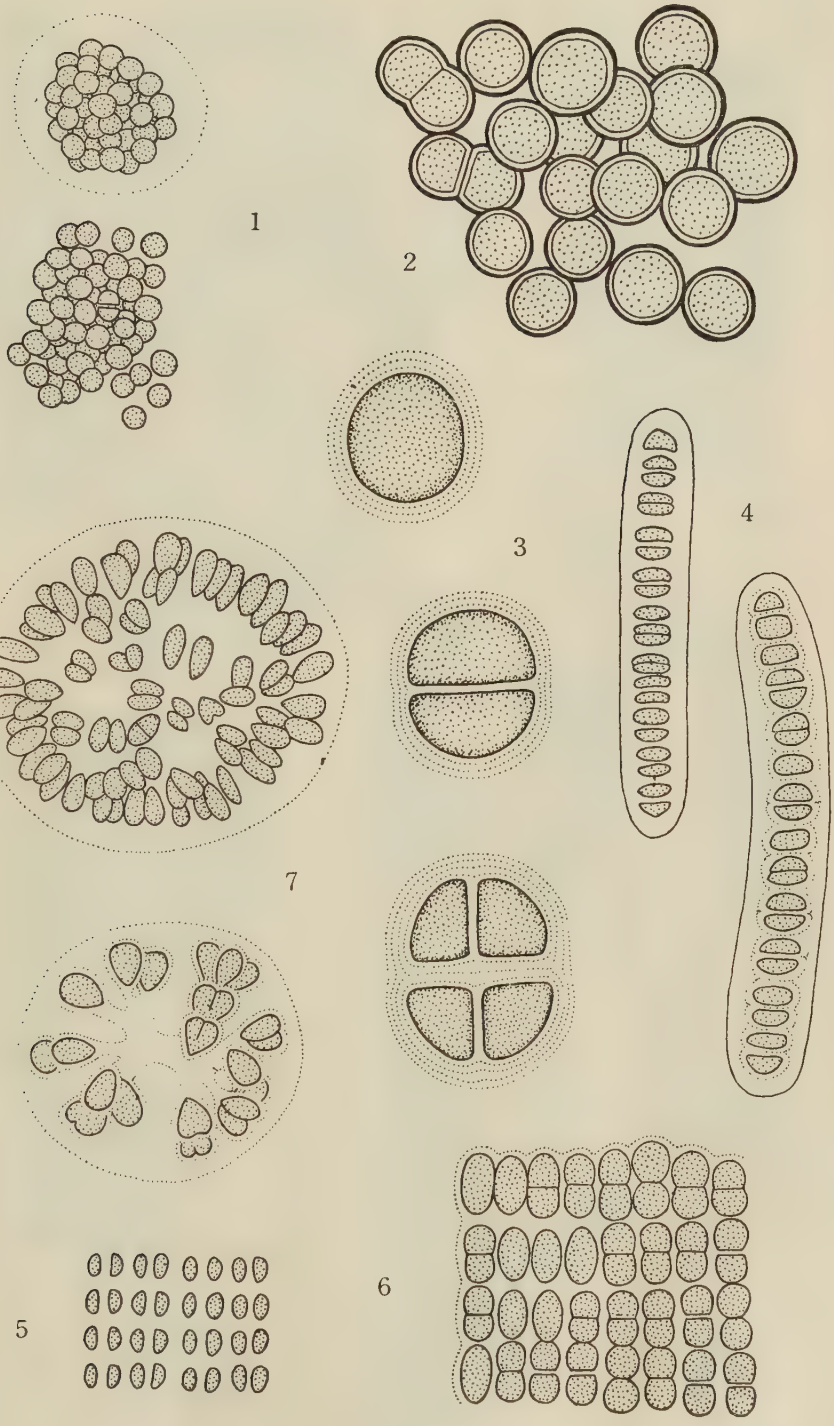
Fig. 1. *Isactis plana* (Harv.) Thur. a, vertical section of a part of a plant, slightly diagrammatic. ×180. b, vertical section of a small part of a plant. ×600.

Fig. 2. *Rivularia polyotis* (Ag.) Born. & Flah. a, plants. ×½. b, vertical section of a plant, slightly diagrammatic. ×4. c, filaments in the meristematic portion of a plant in vertical section. ×500.

Plate 21

Fig. 1. *Rivularia nitida* Ag. a, plants. ×⅔. b, vertical section of a plant, slightly diagrammatic. ×3. c, filaments in the vertical section of a small part of a plant. ×600.

Fig. 2. *Rivularia atra* Roth. a, plants on stone. ×½. b, vertical section of a plant, slightly diagrammatic. ×6. c, filaments in the meristematic portion of a part of a plant in vertical section. ×600.



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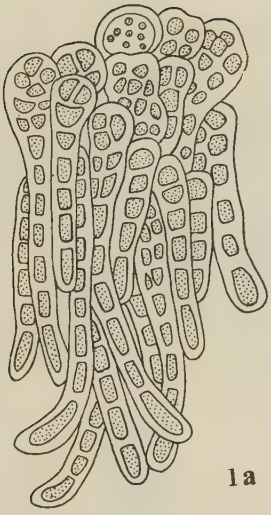

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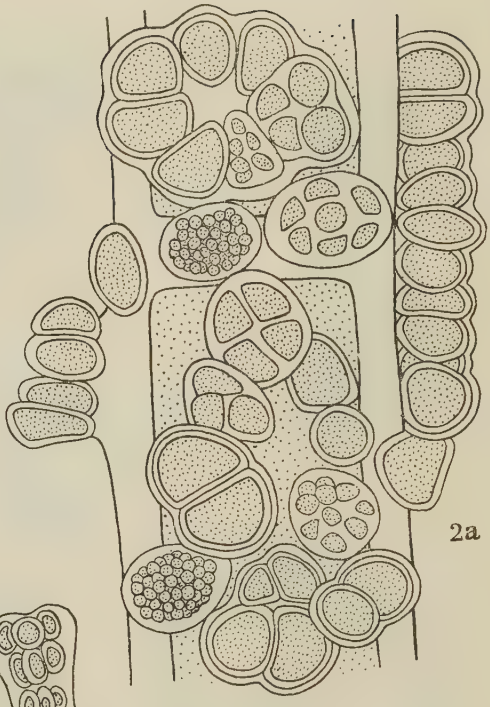
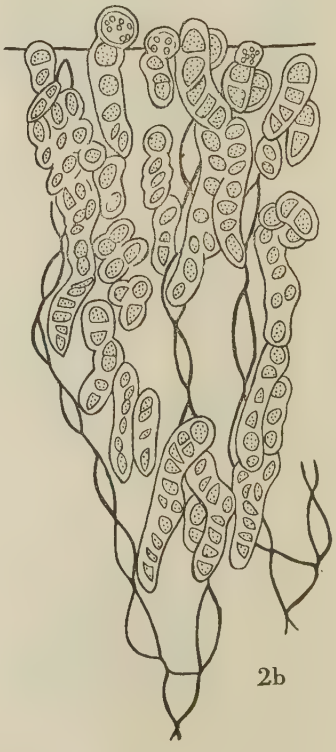


2a

1b

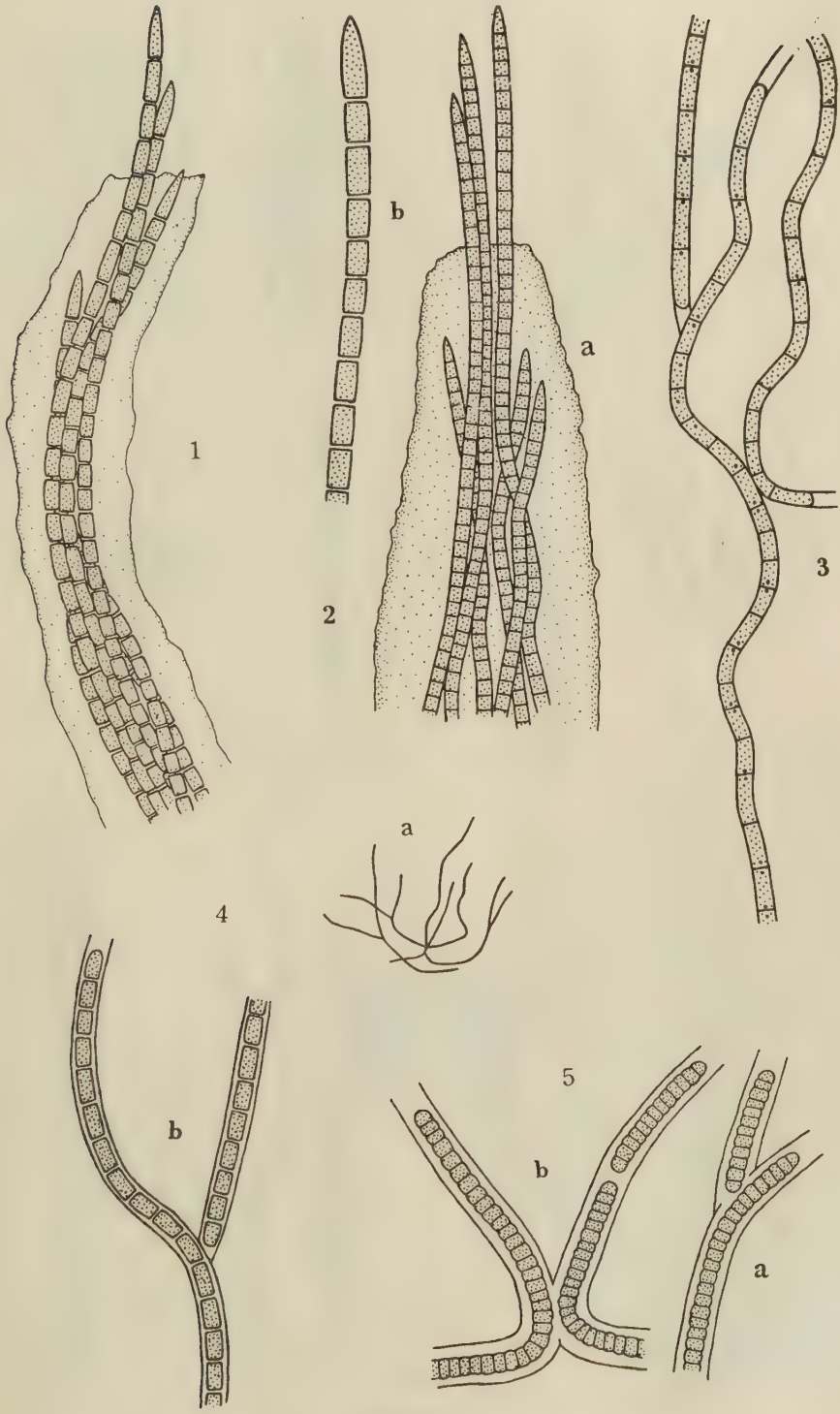


2b

Plate 2

Plate 3

Plate 4



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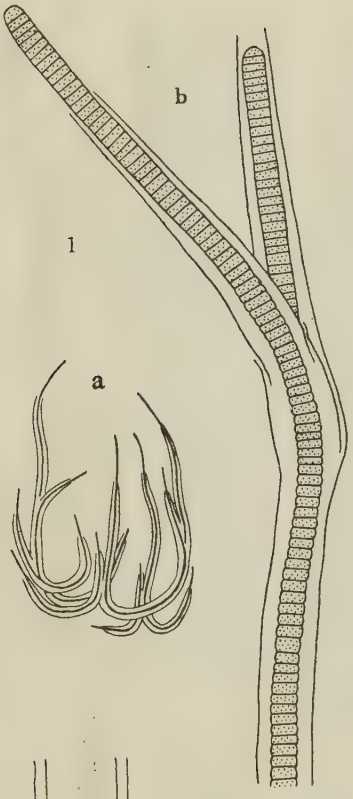
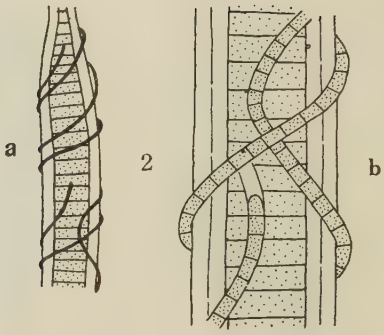
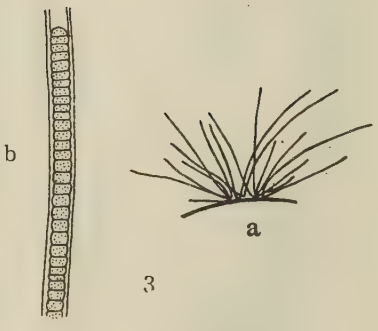
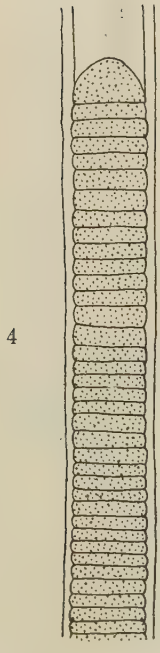
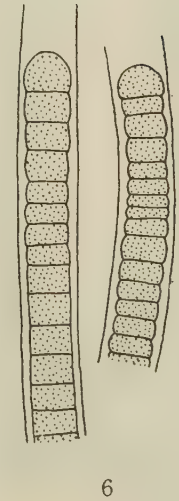










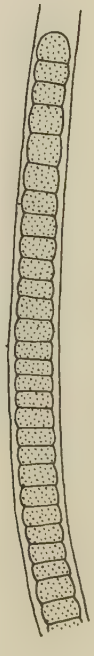
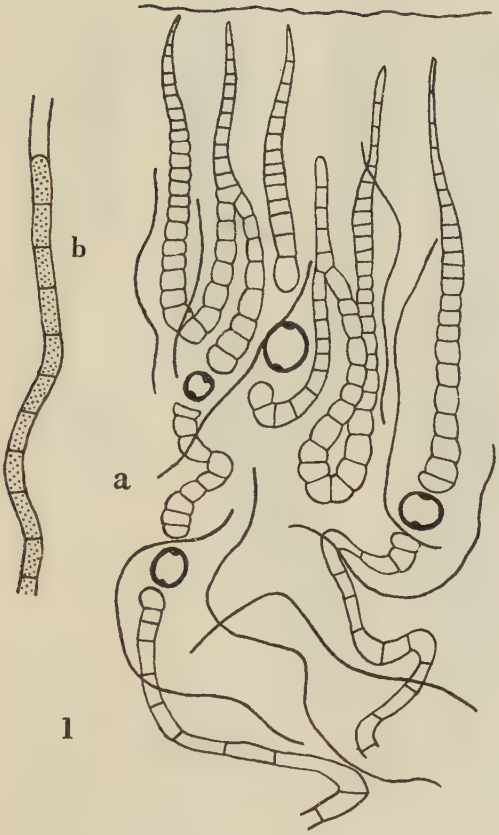
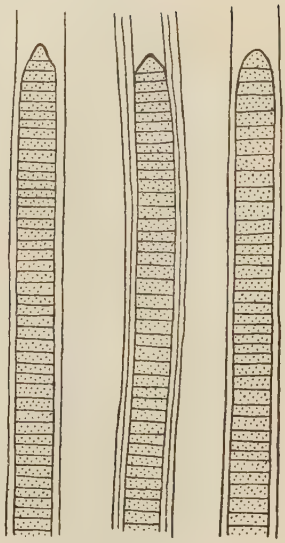
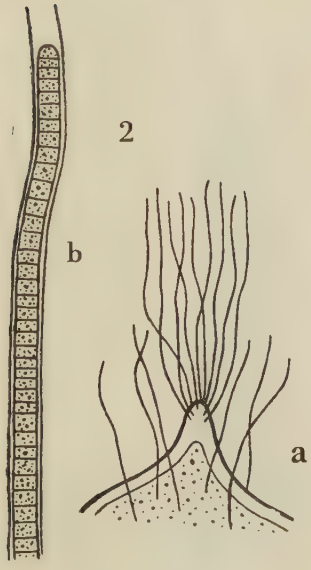


Plate 6







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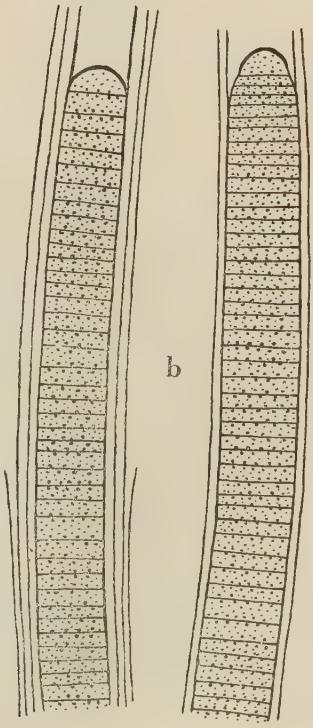
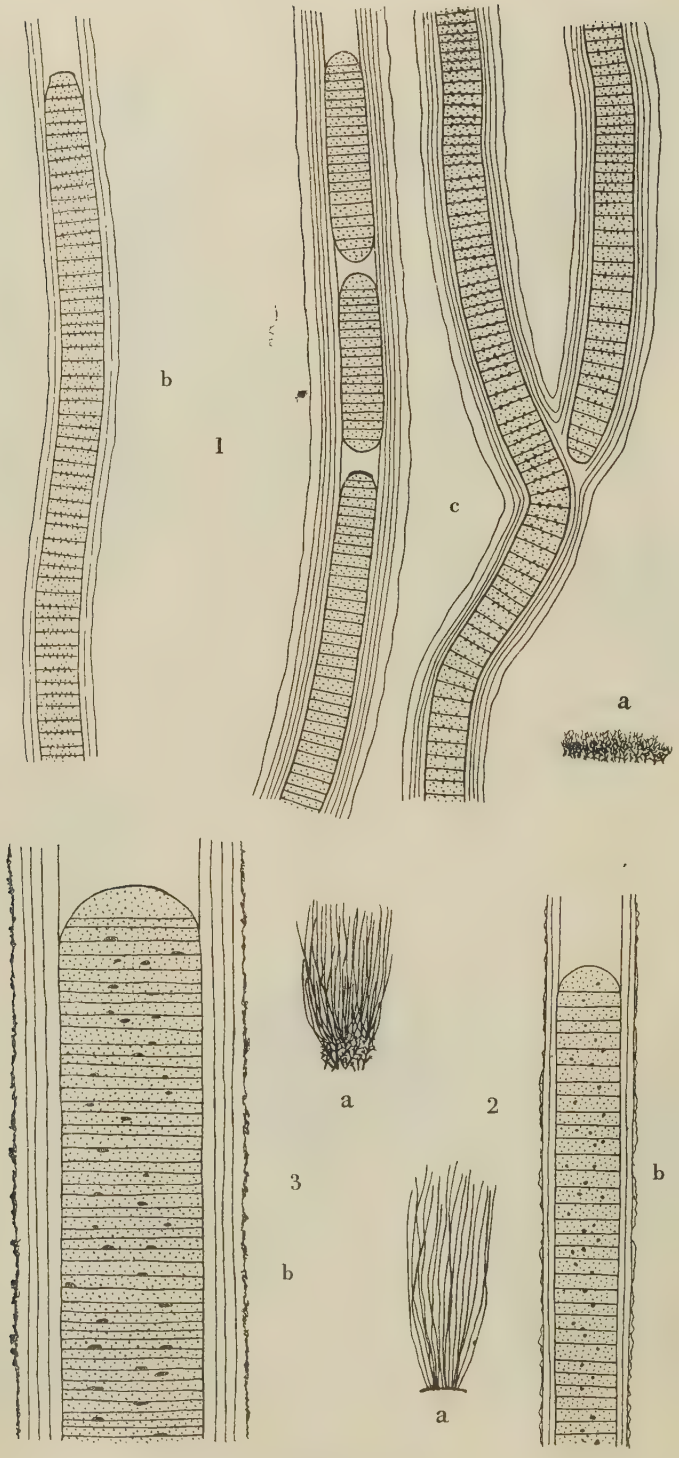


Plate 7



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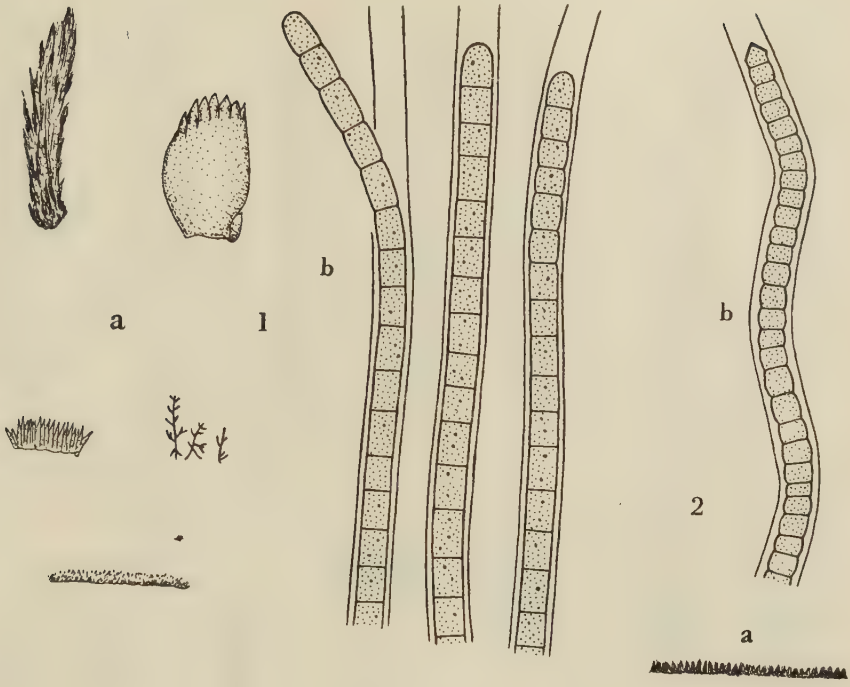

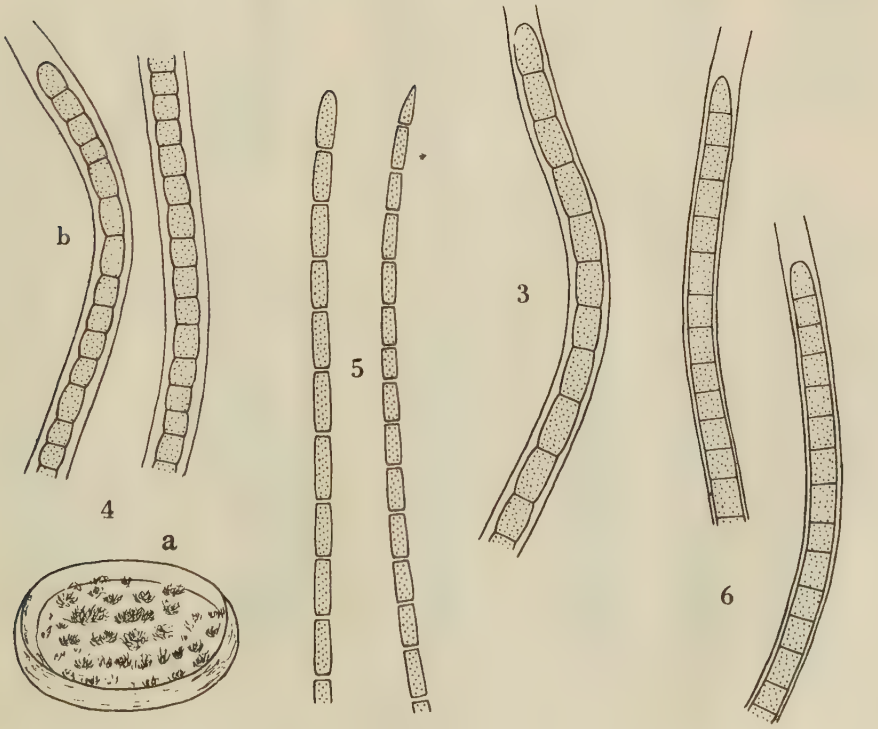

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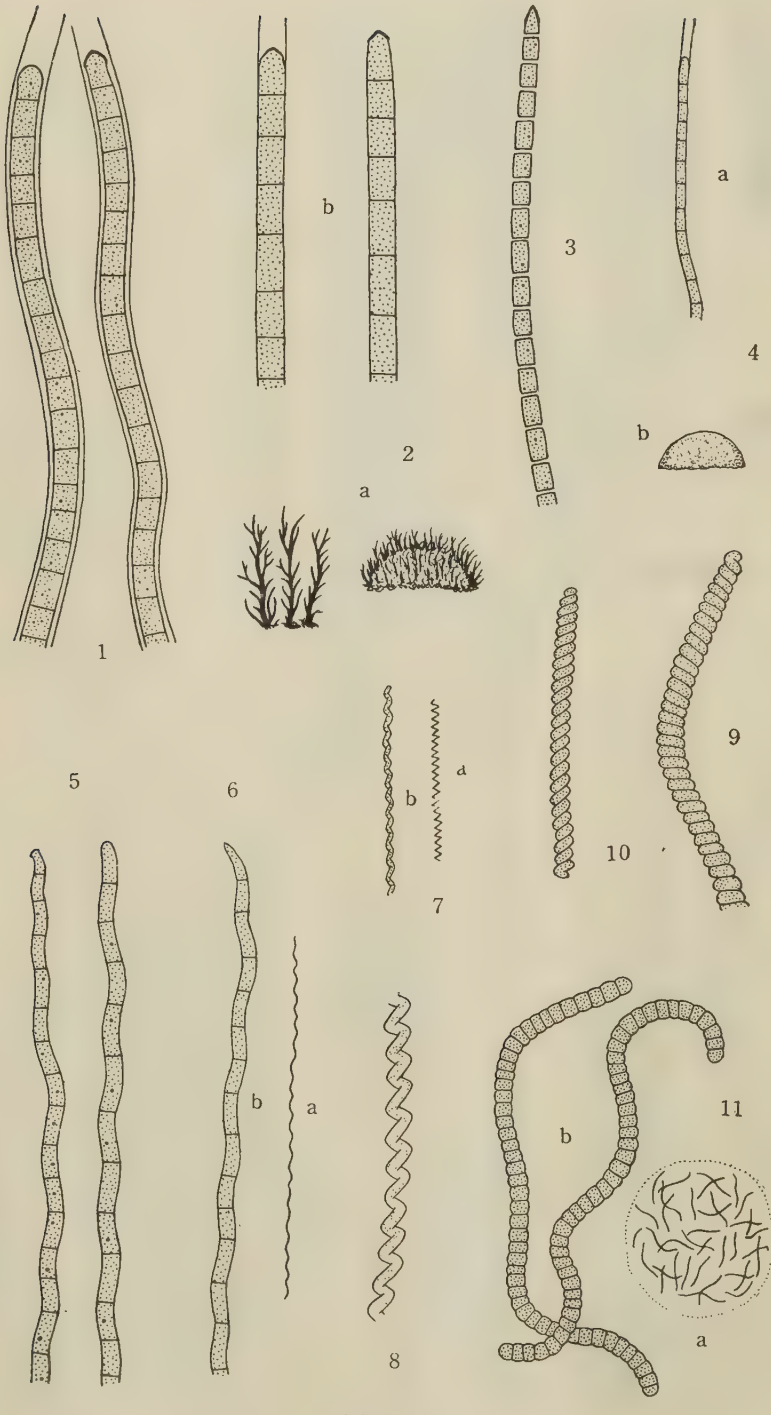

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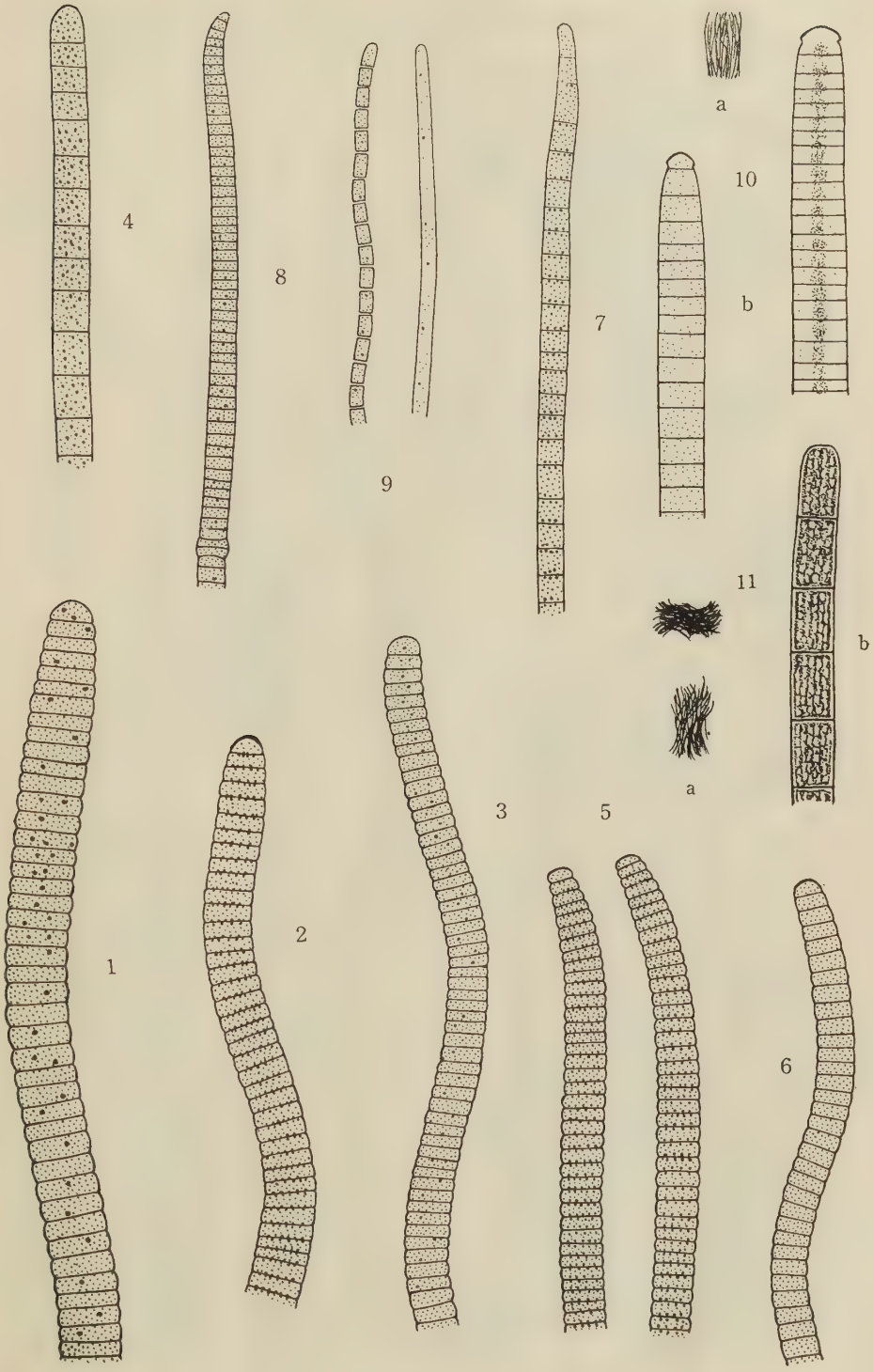

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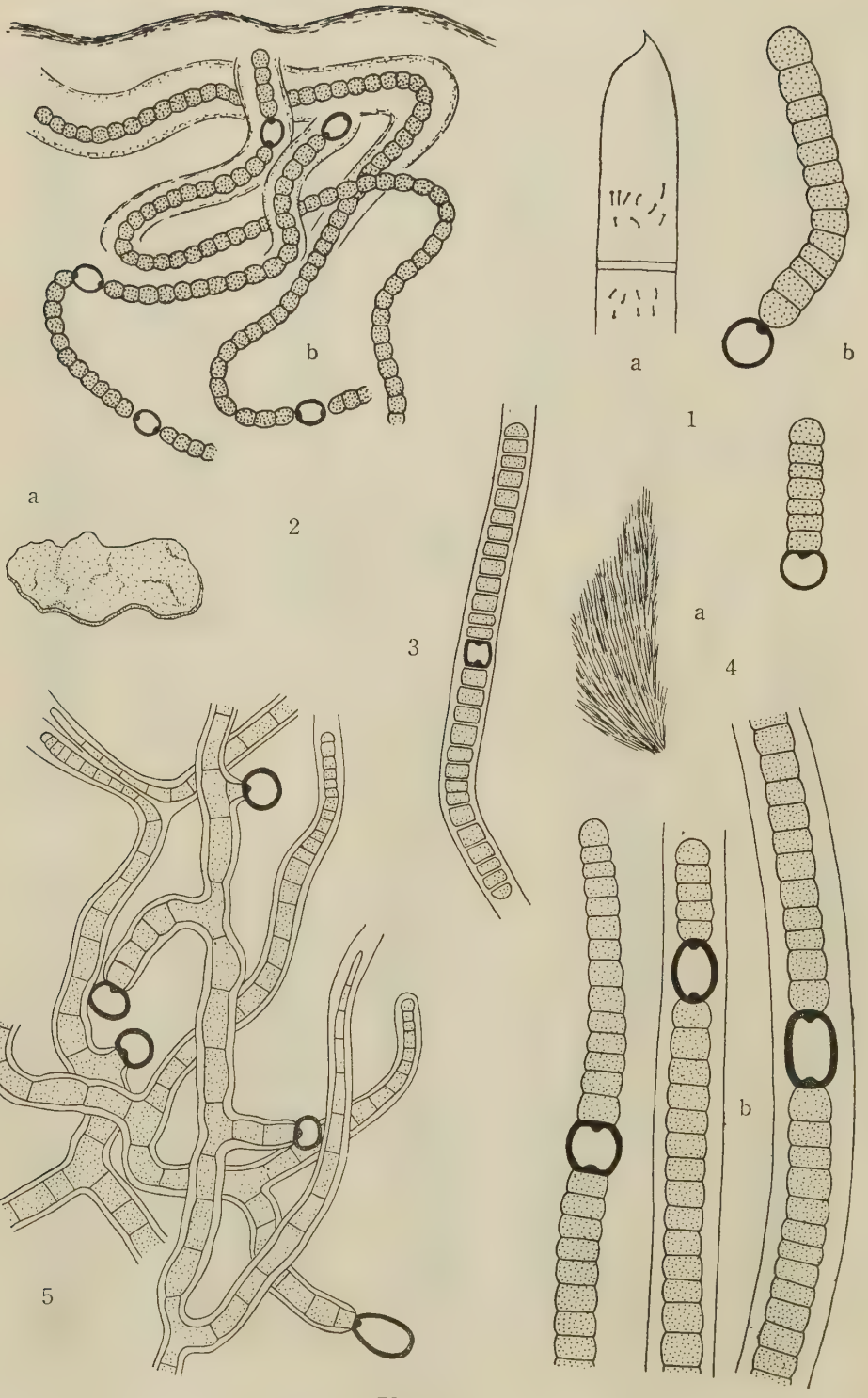

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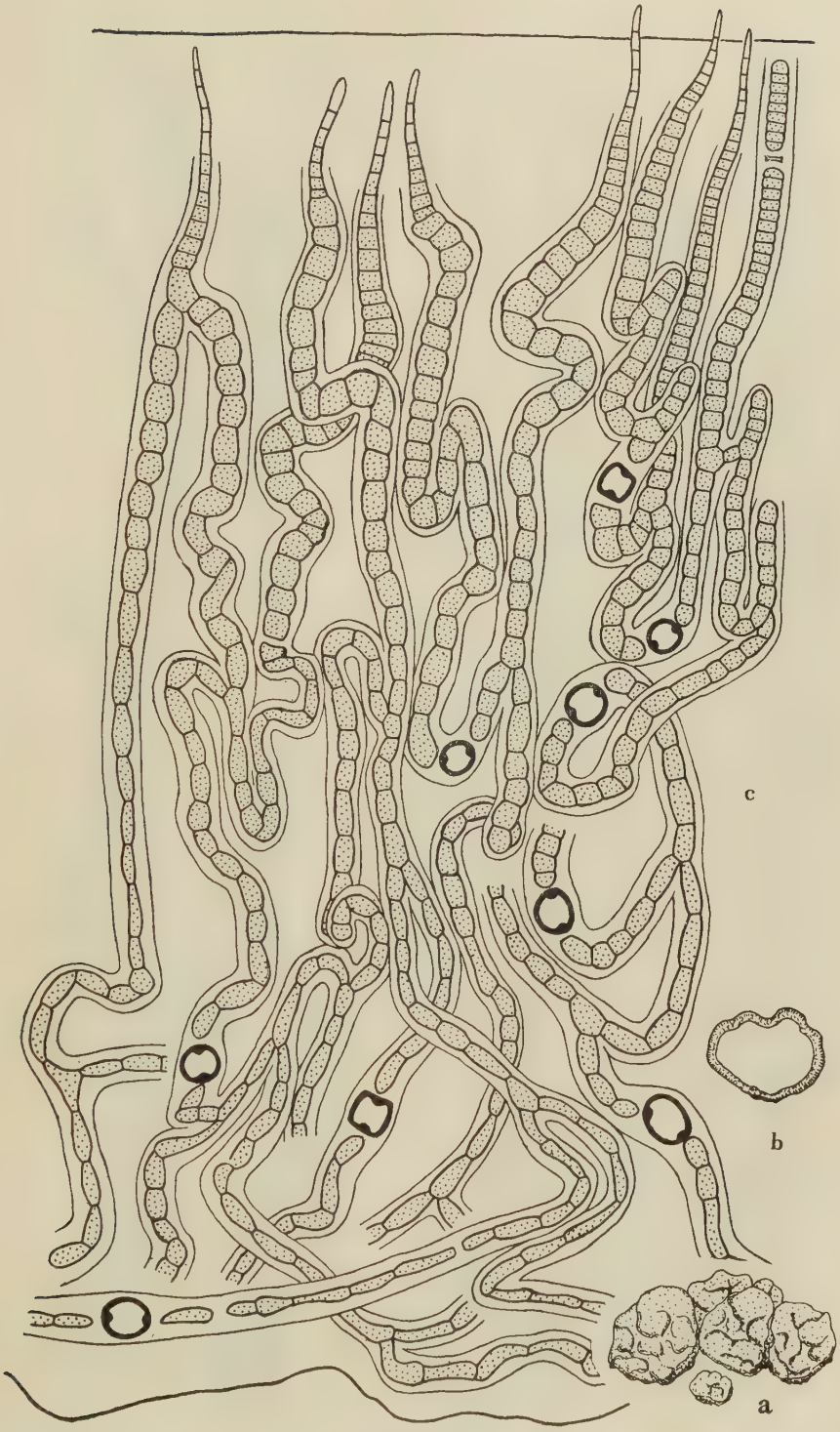

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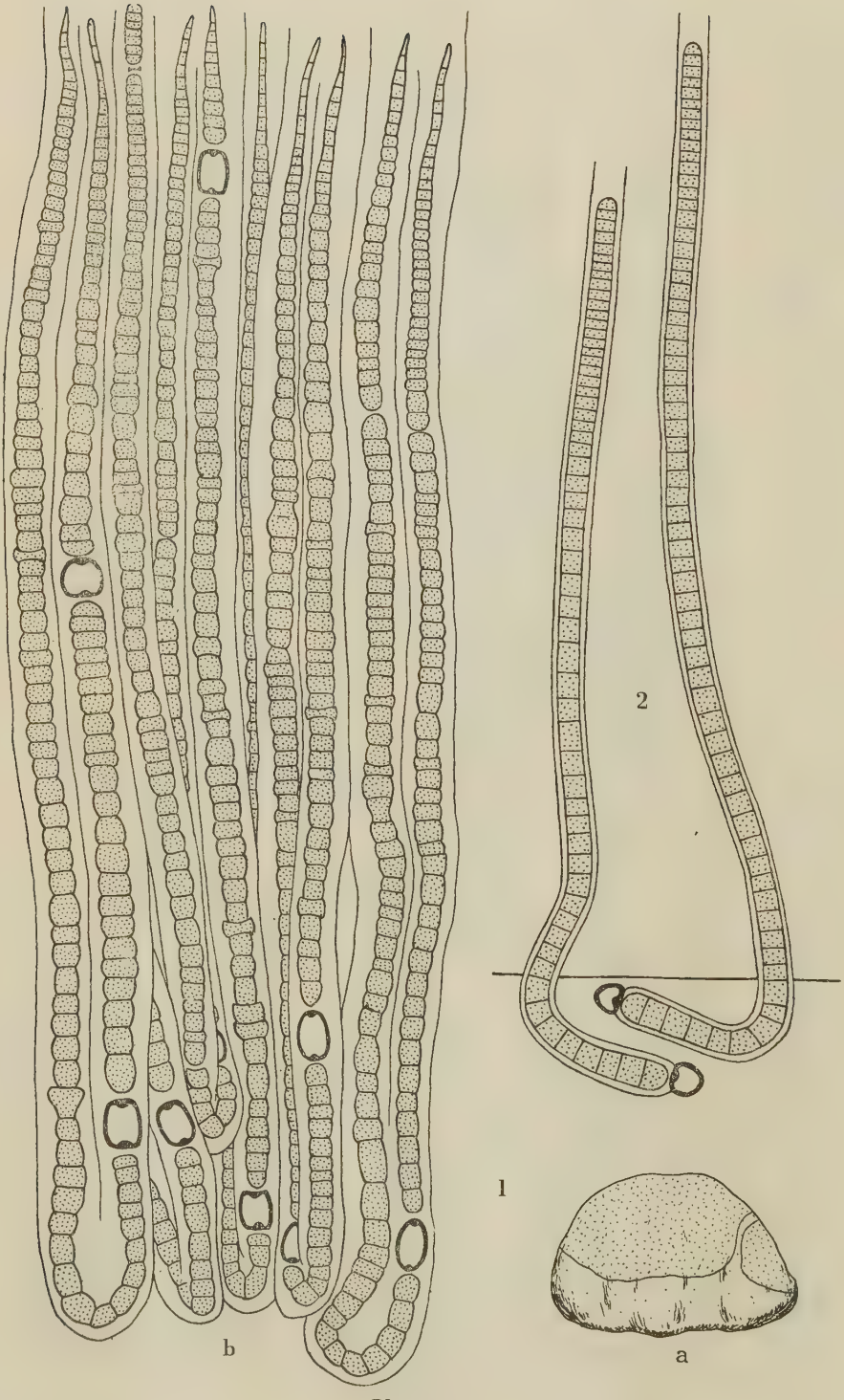

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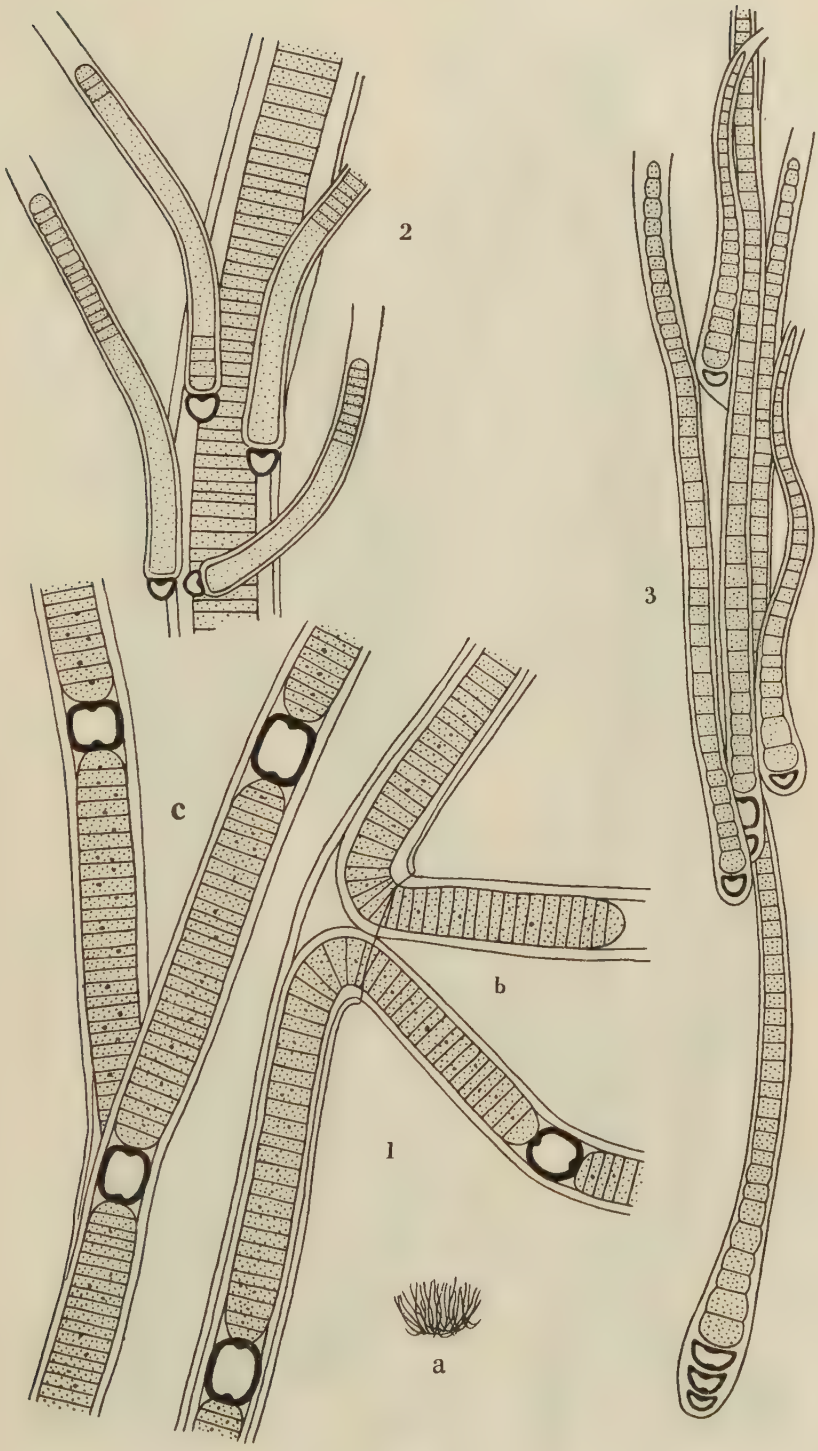

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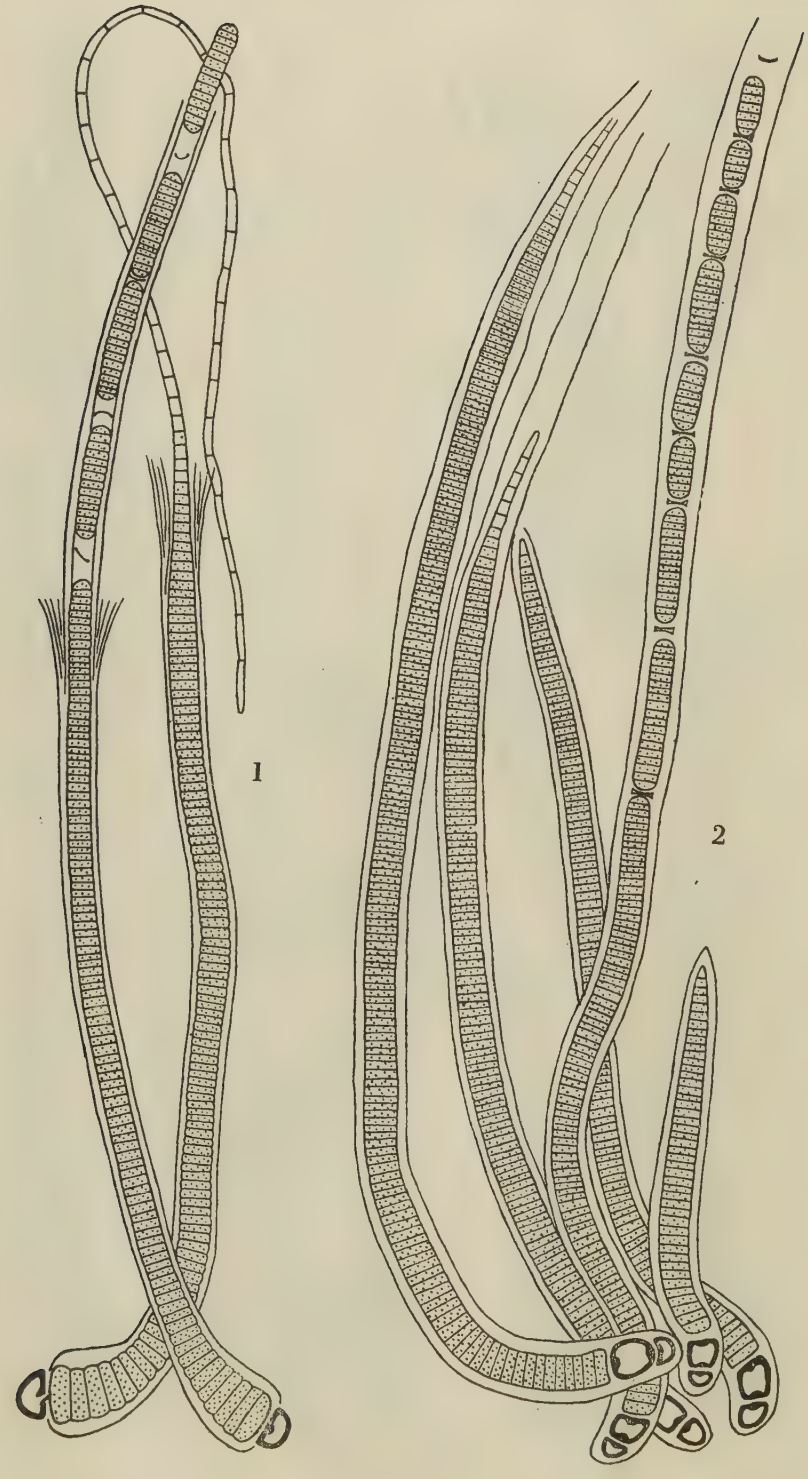
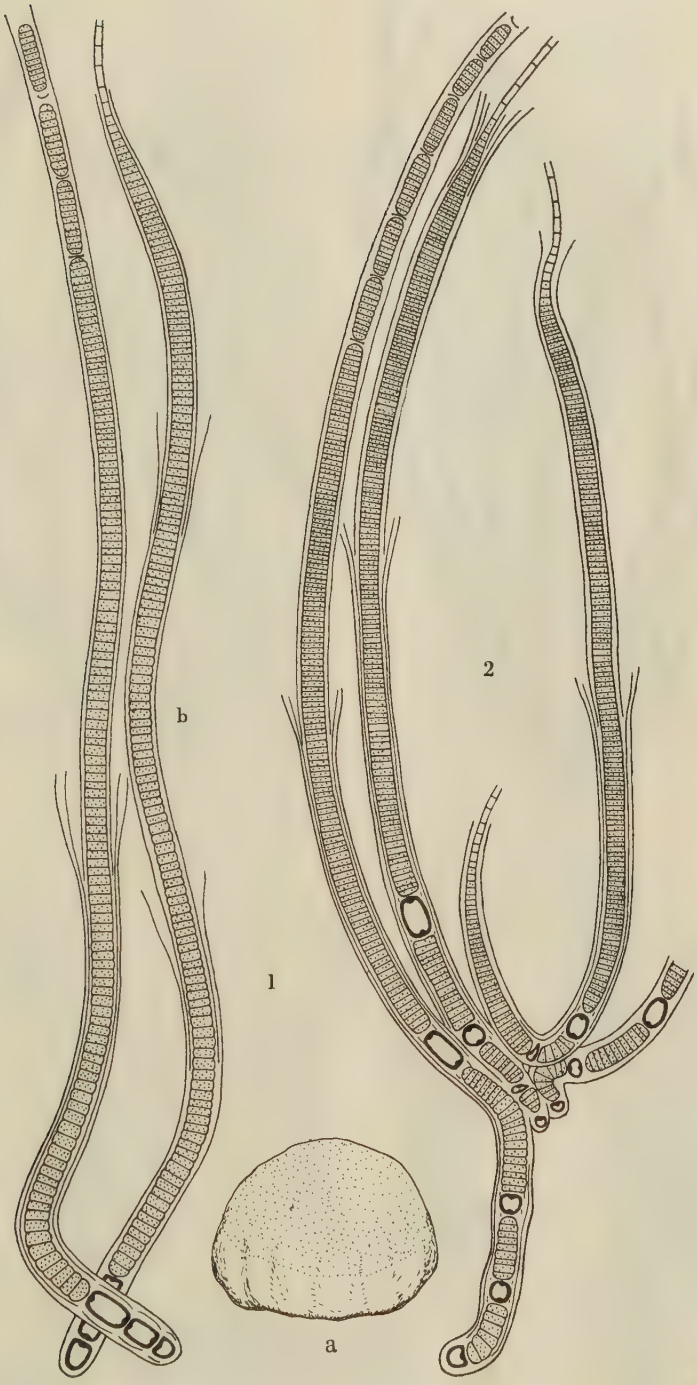


Plate 16



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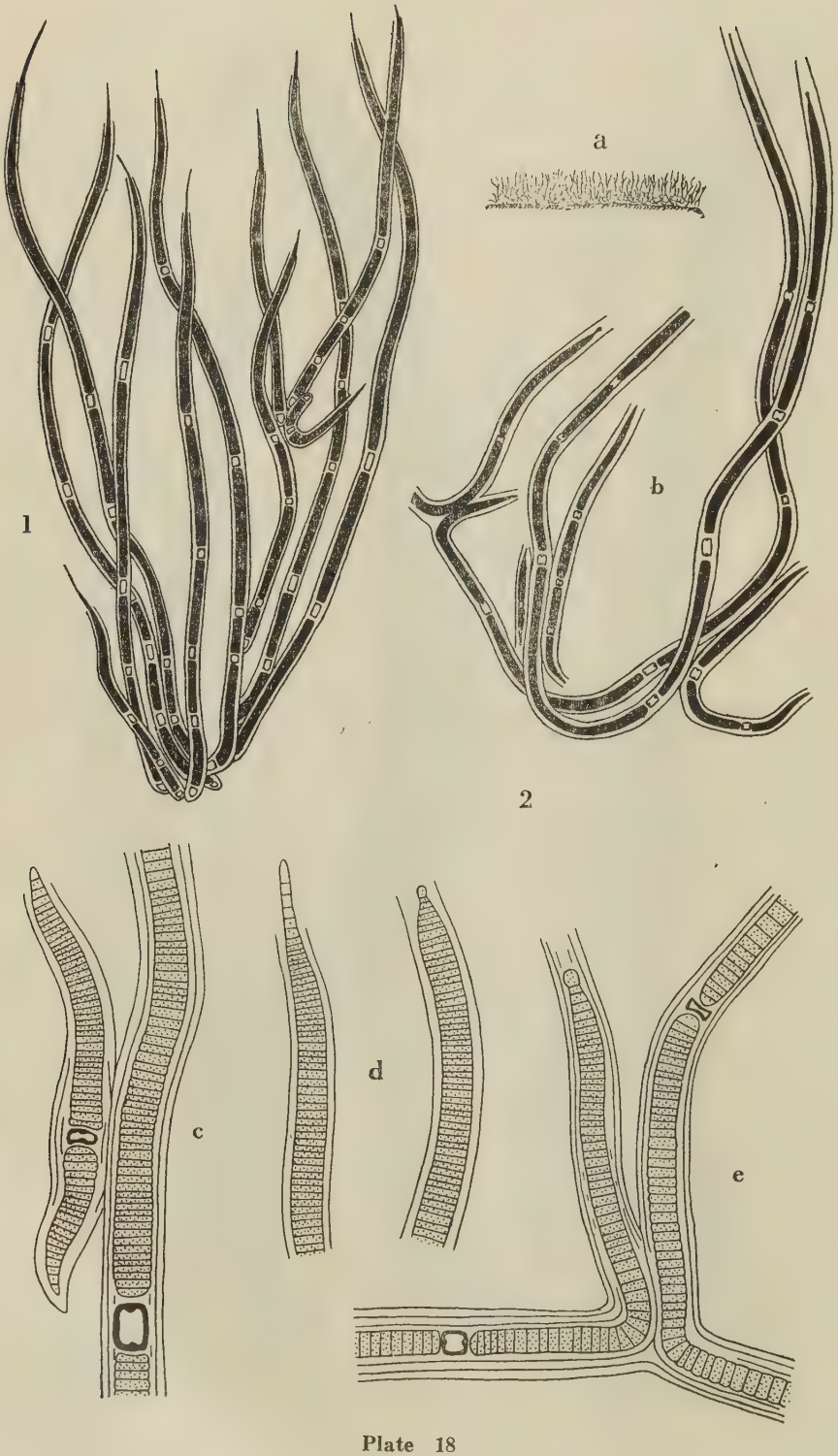

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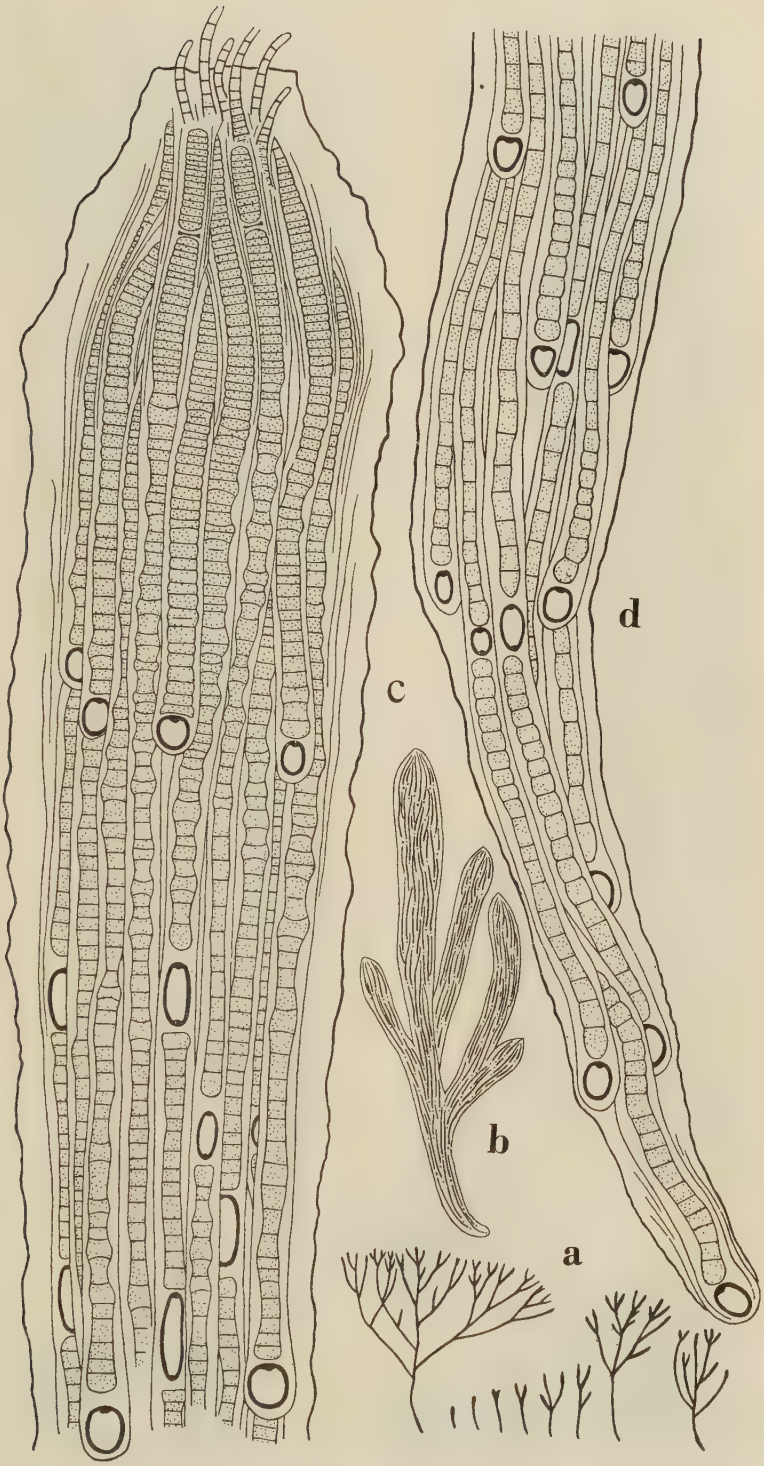

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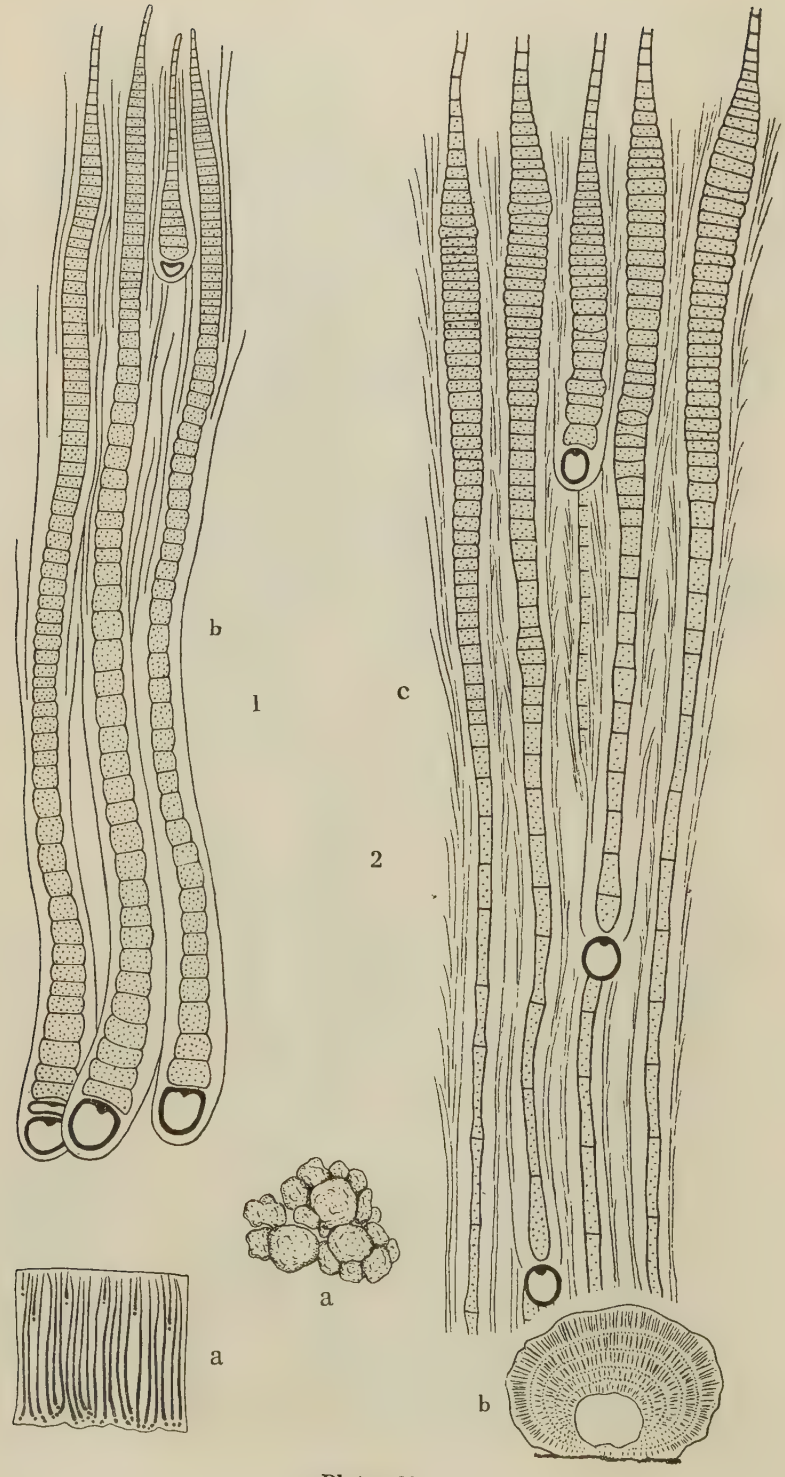

Plate 20

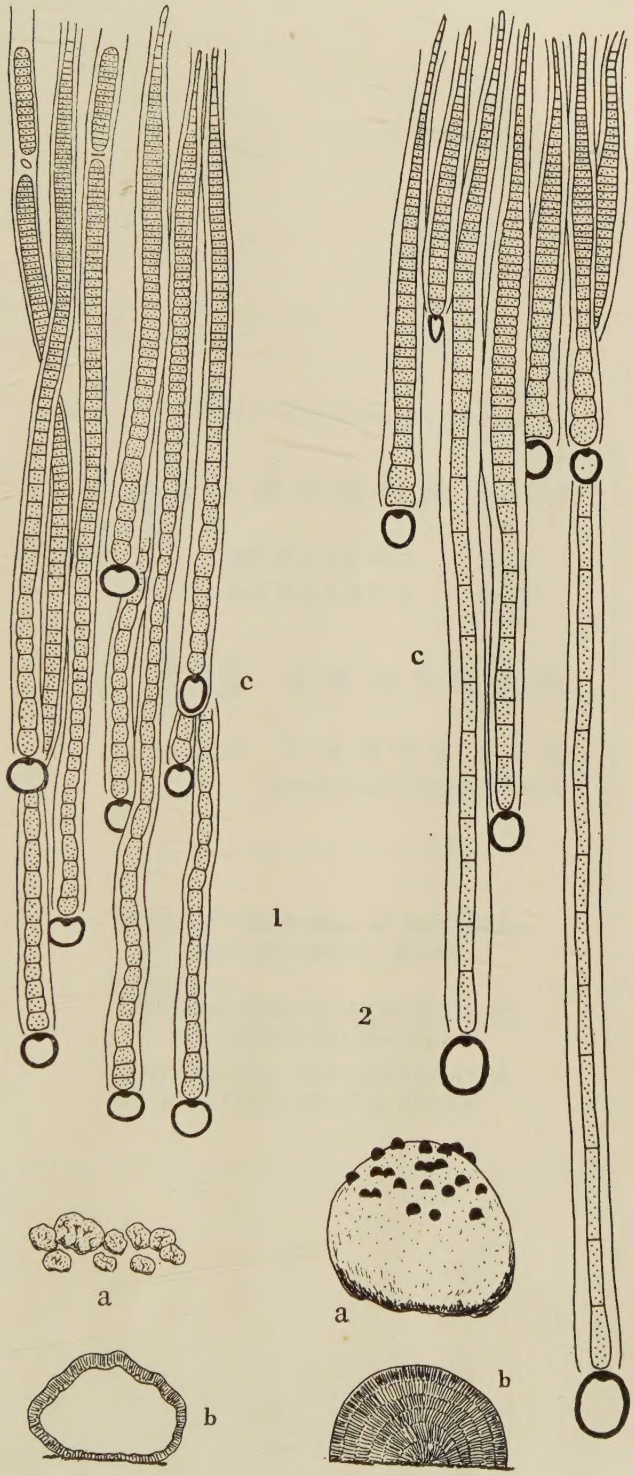

Plate 21

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*No. 1.	May	1926	(Entom. Ser. No. 1)
No. 2.	Nov.	1926	(Chem. Ser. No. 1)
No. 3.	Nov.	1927	(Phytopa. Ser. No. 1)
No. 4.	Nov.	1927	(Chem. Ser. No. 2)
No. 5.	Sept.	1928	(Chem. Ser. No. 3)
No. 6.	Oct.	1928	(Chem. Ser. No. 4)
No. 7.	Nov.	1928	(Phytopa. Ser. No. 2)
No. 8.	Feb.	1930	(Chem. Ser. No. 5)
No. 9.	Feb.	1930	(Chem. Ser. No. 6)
No. 10.	April.	1930	(Entom. Ser. No. 2)
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*No. 12.	Feb.	1931	(Chem. Ser. No. 8)
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*No. 14.	Feb.	1931	(Bot. Ser. No. 1)
No. 15.	Nov.	1931	(Chem. Ser. No. 9)
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No. 46.	March	1939	(Hort. Ser. No. 1)
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No. 57.	July	1950	(Chem. Ser. No. 24)
No. 58.	Sept.	1951	(Phytopa. Ser. No. 10)
No. 59.	March	1951	(Fish. Ser. No. 1)
No. 60.	March	1951	(Chem. Ser. No. 25)
No. 61.	Nov.	1951	(Phytopa. Ser. No. 11)
No. 62.	March	1952	(Fish. Ser. No. 2)
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No. 64.	Jan.	1952	(Bot. Ser. No. 2)
No. 65.	Dec.	1952	(Chem. Ser. No. 27)
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No. 68.	Feb.	1955	(Fish. Ser. No. 4)
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No. 73.	July	1955	(Chem. Ser. No. 29)
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No. 77.	Feb.	1958	(Agri. Econom. No. Ser. 1)
No. 78.	March	1958	(Chem. Ser. No. 30)
No. 79.	Dec.	1958	(Agri. Econom. Ser. No. 2)
No. 80.	Macrh	1959	(Phytopa. Ser. No. 12)
No. 81.	March	1959	(Chem. Ser. No. 31)
No. 82.	Feb.	1960	(Plant Breeding Ser. No. 1)

(No exchange the asterisked Numberes)